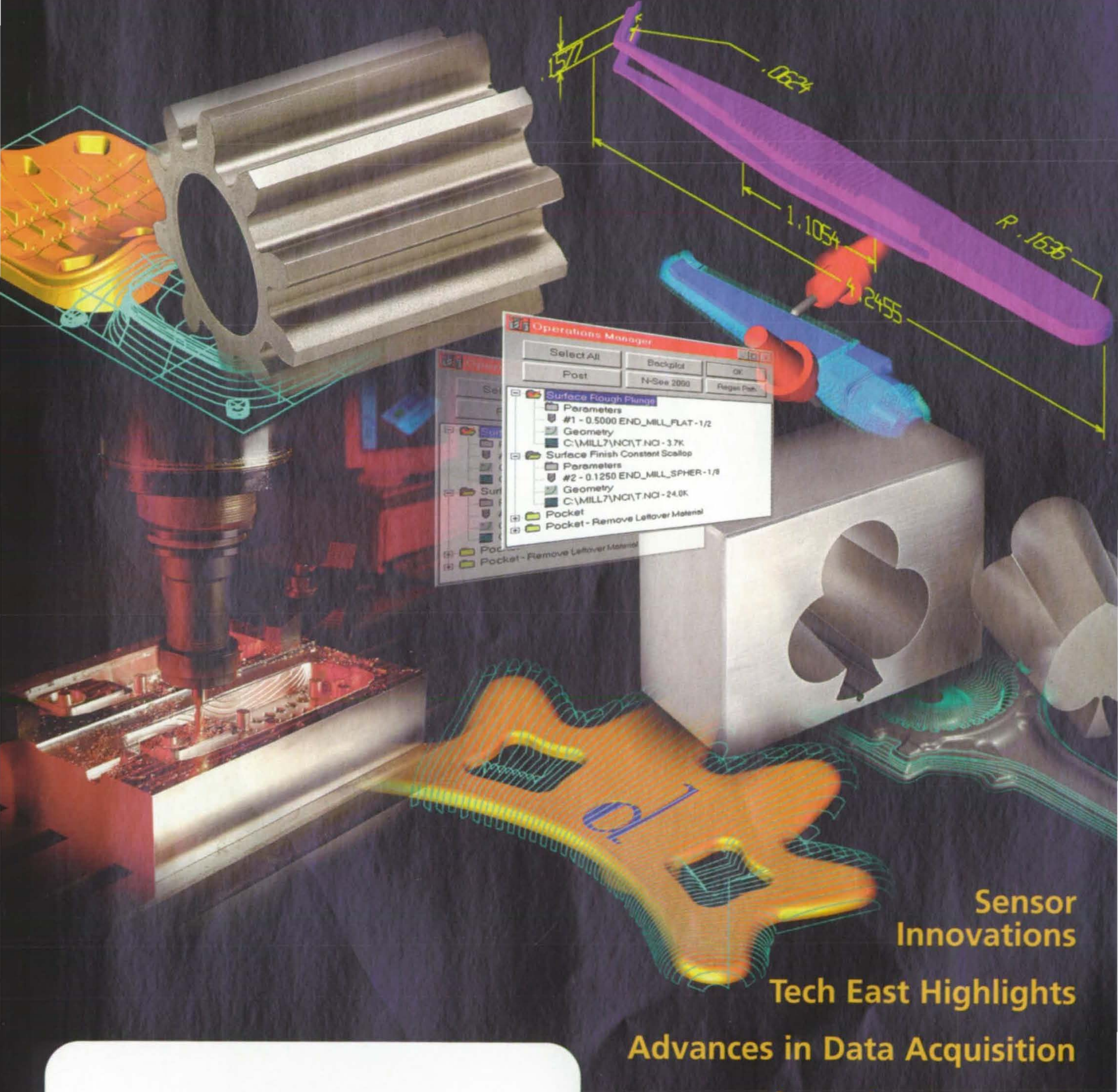
January 2000
Vol. 24 No. 1

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING



Sensor Innovations

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Photonics Tech Briefs

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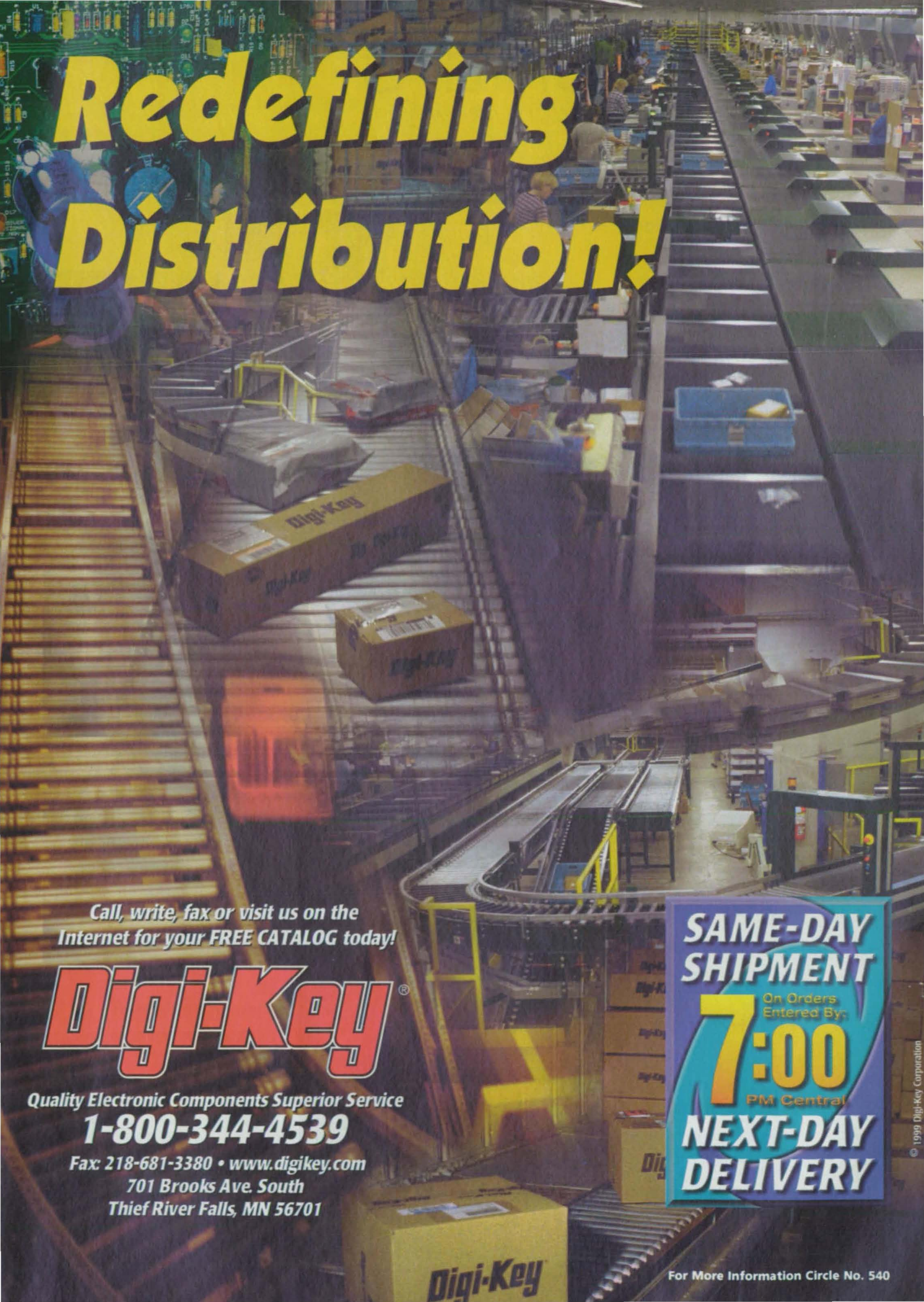
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January 2000 • Vol. 24 No. 1

FEATURES

BRIEFS

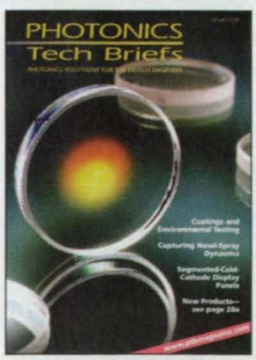
33

60

61

DEPARTMENTS

SPECIAL SUPPLEMENTS



Contents *continued*

PRODUCT OF THE MONTH

Labtec's new 3D motion controller/input device is ergonomically designed for right- or left-hand use.

14

ON THE COVER

This month, *NASA Tech Briefs* introduces a new web publication called Rapid Product Development (RPD) Online. Available at www.rapidproducts.net, RPD Online is designed to help engineers develop products faster by giving them access to feature stories, interviews, show coverage, and other information on CAD, FEA, modeling, reverse engineering, and rapid prototyping. RPD Online also will feature new products, including the latest version of Mastercam CAD/CAM software — from CNC Software, Tolland, CT (www.mastercam.com) — which was used to create the models on our cover. For more information on RPD Online, see page 16.

(Image courtesy of CNC Software)

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NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (609) 667-7737 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
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Hank Davis
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hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
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gale.allen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
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(757) 864-6006
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John H. Glenn Research Center at Lewis Field
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@grc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(256) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
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Kirk Sharp
(228) 688-1929
technology@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
(508) 870-0042

J. Ronald Thornton
Southern Technology Applications Center
University of Florida
(352) 294-7822

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(409) 845-8762

Lani S. Hummel
Mid-Atlantic Technology Applications Center
University of Pittsburgh
(412) 383-2500

Chris Coburn
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(440) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
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(202) 358-4652
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wsmith@sm.ms.ossa.hq.nasa.gov

Roger Crouch
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rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

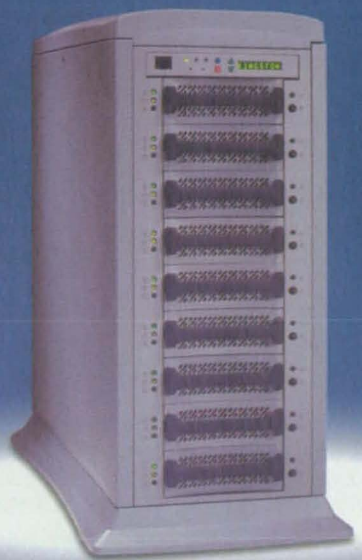
Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

B. Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.



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Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

I am looking for information and manufacturers of bi-directional air sensors, specifically in the range of ±5 feet/minute (0.06 mph). I have found some types, but I'm looking for other units that may be applied to cleanroom applications. Any assistance would be appreciated. Thanks.

John Victor
jvictor@engsvcs.com

In the September 1999 issue of NASA Tech Briefs, *you included a brief entitled "Mixed-Carbon Anodes for Improved Li-ion Cells," by Jet Propulsion Laboratory (page 46). In the brief, the trade name of Chevron's petrochemically derived acetylene black, Shawinigan Black, was misspelled. The research in this article verifies the effectiveness of our acetylene black in significantly improving cycle-life performance. I'd also like to offer our e-mail address, aceblack@chevron.com, for those interested in more information and/or samples.*

Cindy French
lwie@chevron.com

I'm looking for metals similar to BeCu or better in thermal conductivity, with hardness greater than 15 Rc. I'd also like to find something more conductive than Ampcoloy materials. Does anyone know of materials like these, and where I can obtain materials that fit these criteria? The metal also has to be machinable without much difficulty, and must be purchased in rods or blocks. Thank you.

Jeff Sauck
sauckje@worldnet.att.net

NASA Tech Briefs *has helped me find sources for machining precision parts, and has provided design/build options for in-house designs of turbine/flowmeter rotors. Thank you for your help.*

Laurence de Quay
Project Engineer
NASA Stennis Space Center
Mississippi
larry.dequay@ssc.nasa.gov

Post your letters to Reader Forum on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864. Please include your name, company (if applicable), address, and phone number or e-mail address.

UpFront

PRODUCT OF THE MONTH

Labtec, Vancouver, WA, has introduced the Spaceball 4000 FLX 3D motion controller/input device that minimizes arm and wrist stress, and features a new, adjustable wrist pad for right- or left-hand use. The device allows users to simultaneously pan, zoom, and rotate 3D models as they build, modify, and inspect their 3D designs within their 3D applications. With six-degrees-of-freedom (6D) motion control, users push, pull, or twist the PowerSensor ball for X, Y, and Z axis translations and rotations. A specially coated surface allows flexibility for finger and thumb placement on the ball surface; a ridge design around the ball guides fingers into the optimum position. The placement of 12 buttons — three on the right and nine on the left — offers access to 22 customized functions, and eliminates the need to reach over the sensing mechanism. The device is driven by the SpaceWare 99 software driver that is available for UNIX and Windows NT/95/98 environments.

For More Information Circle No. 757

What's New Online

Beginning this month, you have a new vehicle to help you develop better products faster. Rapid Product Development Online, a completely web-based publication, provides immediate, 24-hour access to the latest information on CAD, FEA, modeling, reverse engineering, and rapid prototyping tools and techniques. Rapid Product Development (RPD)Online is available at **www.rapidproducts.net**, and includes feature stories updated monthly, industry and product news updated on a continuous basis, product reviews, interviews, show coverage, demos, and links. Look for a monthly RPD Online preview in *NASA Tech Briefs* to find out what's new at **www.rapidproducts.net.** A preview of this month's features can be found on page 16.

The Microlith catalyst-coated metal substrate is in the foreground. Behind it is an automotive Microlith light-off converter and main converter in an integrated car. A standalone Microlith automotive preconverter is on the right.

The Air They Breathe

NASA's Marshall Space Flight Center, Huntsville, AL, is field-testing a small, metal monolith as a potential component of the International Space Station's Trace Contaminant Control System. The monolith is a catalyst-coated metal honeycomb of a specific geometry that allows efficient, direct electrical heating and better catalytic activity than with conventional catalyst substrates.

The technology, called Microlith®, could save NASA up to $31 million over a 15-year period in air-cleaning of space flight life support. Precision Combustion of New Haven, CT, has employed a small amount of electrical heating of the ultra-lightweight metal catalyst substrate to achieve better than 99% destruction of trace organic contaminants at low air inlet temperatures.

The company is conducting research and development with NASA to produce a high specific surface-area washcoat, a specially formulated chemical coating that allows an increased amount of a reactive catalyst to be more evenly and durably applied to the metal monolith.

Non-heated versions of the technology are being evaluated by auto manufacturers for emission concerns. The Microlith enables air-cleaning system designers to use more advanced catalysts, while maintaining safe, low-cost, low-temperature operation.

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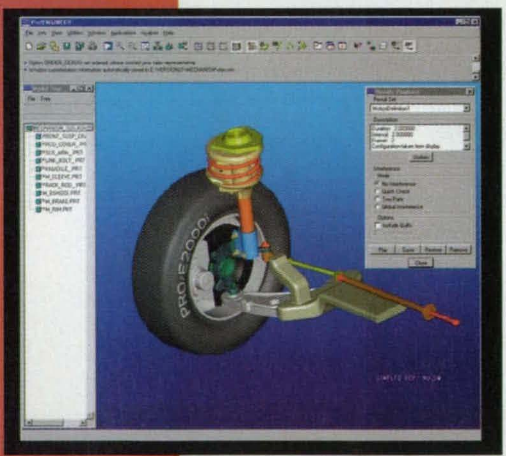

NASA Tech Briefs is proud to introduce this month a new, totally digital publication called Rapid Product Development Online. Available at **www.rapidproducts.net**, RPD Online is designed to help engineers develop better products faster by giving them immediate, 24-hour access to the latest information on CAD, FEA, modeling, reverse engineering, and rapid prototyping tools and techniques.

RPD Online will include feature stories, industry and product news, product reviews, interviews, show coverage, demos, links, and a keyword-searchable supplier guide.

Each month in *NASA Tech Briefs*, we'll give you a preview of what's new in RPD Online. This month's premier edition includes:

- **Behavioral Modeling: The Next Generation of Mechanical Design Automation** — Learn how the challenges of today's design market are forcing organizations to take a smarter, more objective-driven and process-wide approach to product development.
- **Laser System Rapidly Produces 3D Models** — An industrial design school uses a low-cost laser marking and cutting system to produce 3D parts from students' technical designs.
- **Medical Device Maker Cuts Design Time With CAD Software** — This application story describes how Medstone International, a leading medical device maker, used SolidWorks mechanical CAD software to cut prototyping and development time.
- **New Products** — New offerings in reverse engineering, epoxy materials, CAM and cost estimating software, and CNC machining are featured.

Be sure to visit www.rapidproducts.net for the latest information on the rapid product development industry. For advertising and sponsorship information, contact Joe Pramberger at joe@abptuf.org; Tel: 212-490-3999.

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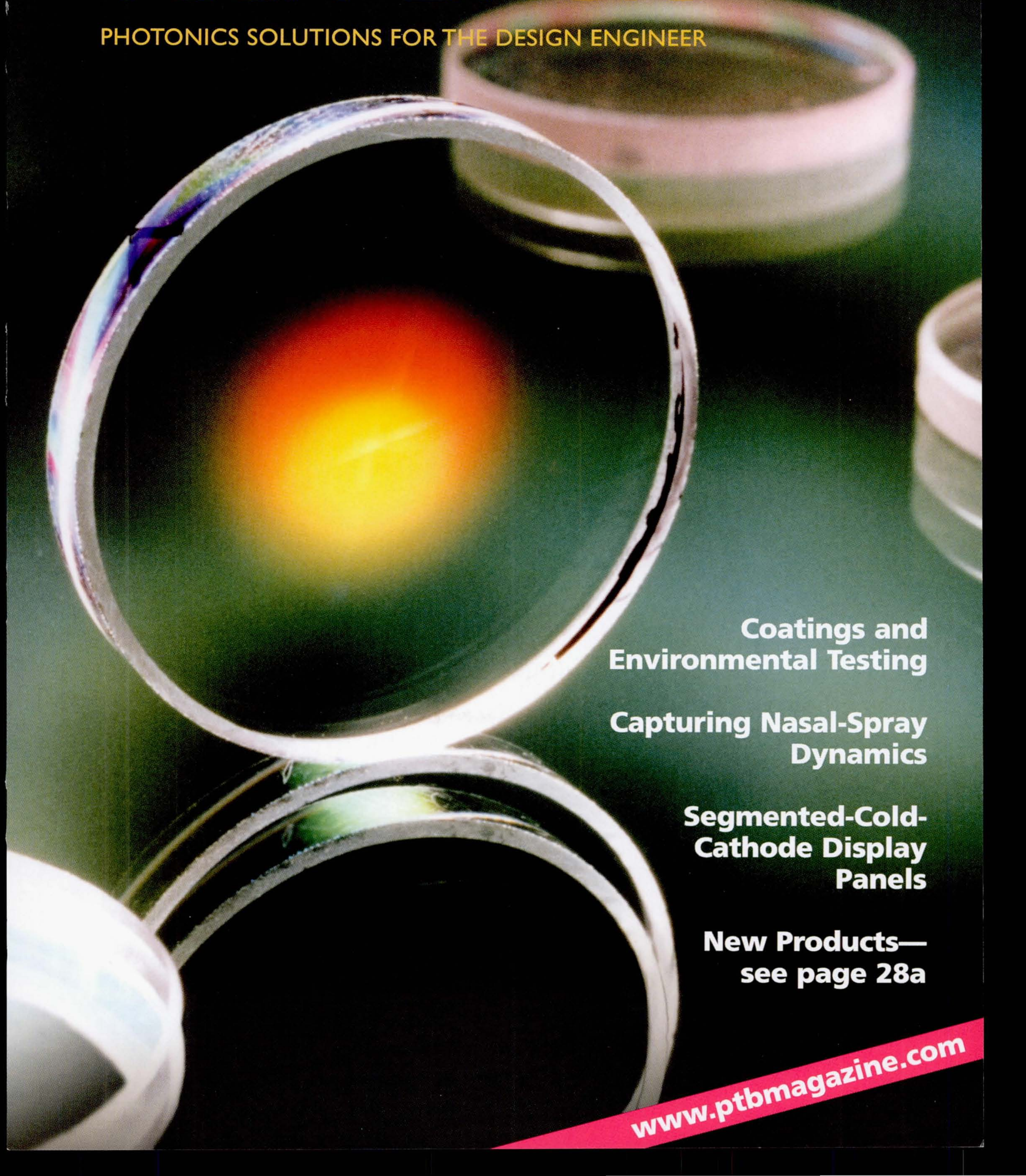
January 2000

PHOTONICS Tech Briefs

PHOTONICS SOLUTIONS FOR THE DESIGN ENGINEER



Coatings and Environmental Testing

Capturing Nasal-Spray Dynamics

Segmented-Cold-Cathode Display Panels

New Products—see page 28a

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PHOTONICS Tech Briefs

Supplement to *NASA Tech Briefs'* January 2000 Issue
Published by Associated Business Publications International

Features

Tech Briefs

Departments

Cover photo: Lasiris's new APM line of apodized phase masks have a spatially varying first-order diffraction efficiency that generates a special apodization profile to reduce the sidelobes in the Bragg response of the fiber grating. *Photo courtesy Lasiris Inc., a Stocker and Yale company.*

New

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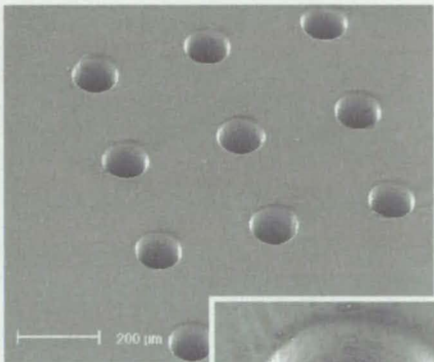

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SPIE—The International Society for Optical Engineering serves both individual and corporate members. The Society offers the following services for the companies that develop, distribute, and market optical, optoelectronic, photonics, and imaging technologies.

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- Focused technical exhibits—Microlithography, Medical Imaging, Micromachining/Microfabrication, Smart Structures, and AeroSense with its focus on defense/sensing controls and simulation;
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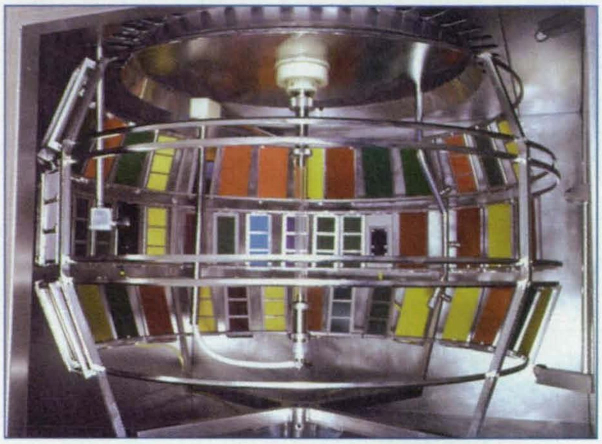

Figure 1. The Atlas Ci4000 Weather-Ometer.

The response and resistance of products to the effects of weathering is of concern in a wide variety of industries. Typical examples include automobiles (exterior finish, paint, upholstery, plastics, trims), fabrics (clothing, carpeting, wall coverings, outdoor furniture), building materials (lumber, roofing), architectural coatings (paint, vinyl siding), toys, bicycles, and camping equipment, to name just a few.

Simply exposing a product under test to the elements, however, is not always the ideal way to perform this type of environmental testing, as the exact exposure conditions cannot be controlled and the process cannot be accelerated. On the other hand, accurately simulating outdoor exposure in the laboratory, especially the effects of natural sunlight, poses its own set of challenges. This article reviews the technology currently in use to perform accelerated weathering, and in particular examines the use of thin-film coatings to better match the output of xenon arc lamps to the natural solar spectrum.

Anatomy of a Weathering Chamber

The three major factors that determine damage to products outdoors are sunlight, moisture (in the form of both humidity and rain), and temperature. Thus, properly simulating outdoor exposure requires the ability to produce a given level of these parameters with accuracy, repeatability, and reproducibility. In this context, repeatability means the consistency of response of a particular testing station when given a specific input, and reproducibility means the unit-to-unit consistency for a specific input. When these three goals are achieved, then a test can be closely correlated with true outdoor exposure. This also enables a manufacturer to make an "apples-to-apples" comparison of the results of testing on various product formulations to determine which one will work best under a certain set of conditions.

The photo of an actual weathering test chamber, the Atlas Ci4000 Weather-Ometer®, illustrates how such testing is implemented in practice (Figure 1). A high-intensity xenon arc lamp line source sits at the center of a stainless steel chamber. Specimens of the materials under test are placed on a barrel-shaped rack that rotates about the center of the lamp. This shape and motion of the rack are designed to enhance irradiation uniformity. A blower, sitting atop the unit, is used to draw air through the chamber. An array of water nozzles is available to produce "rain." Additionally, atomized water can be introduced into a compressed-air stream to enable any arbitrary chamber humidity within a certain range to be reached.

The lamp output is intended to simulate sunlight; some of it is channeled through a light pipe to an ultraviolet (UV) bandpass filter, and then on to a photodetector. This signal is then used in a closed-loop system to stabilize source output. The lamp is monitored in the UV for two reasons. First, most material degradation occurs because of UV exposure, so maintaining constant UV output is critical to achieving high accuracy, repeatability, and reproducibility. Second, the lamps themselves tend to degrade more quickly in the UV than they do in the visible or infrared (IR) portions of the spectrum.

A unique patented feature of the Weather-Ometer is its ability to independently control both chamber air temperature and the "Black Panel" temperature, which is an industry standard that is meant to represent worst-case surface temperature of the parts under test (due to heating by the light source). Air temperature is continuously monitored and regulated by opening or closing a damper, which in turn limits the ability of the blower fan to draw air through the chamber. Typically, the Black Panel temperature is measured by a resistance temperature device welded to a metal panel that is painted black and placed in the sample rack.

In operation, air temperature, sample temperature, humidity, and part irradiance can be held constant at various levels to simulate the type of exposure experienced at different locations (northern versus tropical latitudes) or during different seasons at a given location; alternately, exposure parameters can be cycled to simulate diurnal variations or the effects of specific weather patterns.

Accelerated Testing

Besides allowing precise control of exposure parameters, another important benefit of this type of environmental testing is that it enables acceleration of the weathering process. Obviously, when testing a product designed to withstand ten years of exposure, it is not practical to take that long to perform the experiment.

Accelerated testing is accomplished through two means. First, the percentage of time a part is exposed to sunlight during a 24-hour period can be increased up to 100 percent. In the real world, even during daylight hours, the changing angle of the sun alters the level of exposure experienced out in the open. Thus, maintaining a noontime light level over an entire day of testing results in far more than a twofold

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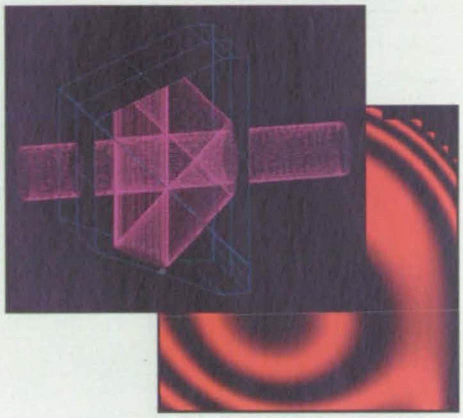

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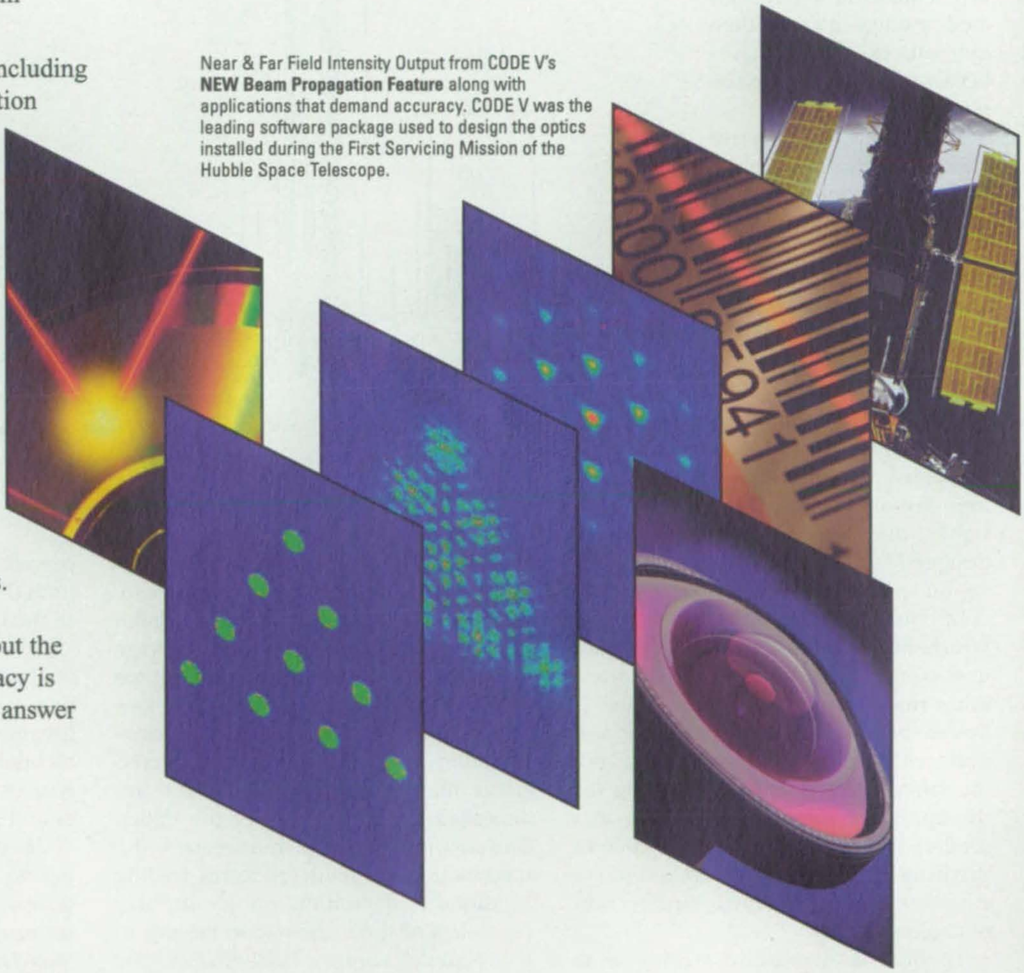

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increase in exposure. The second method of producing acceleration is to use light levels that are greater than "one sun." This can also be accompanied by higher air temperature and humidity.

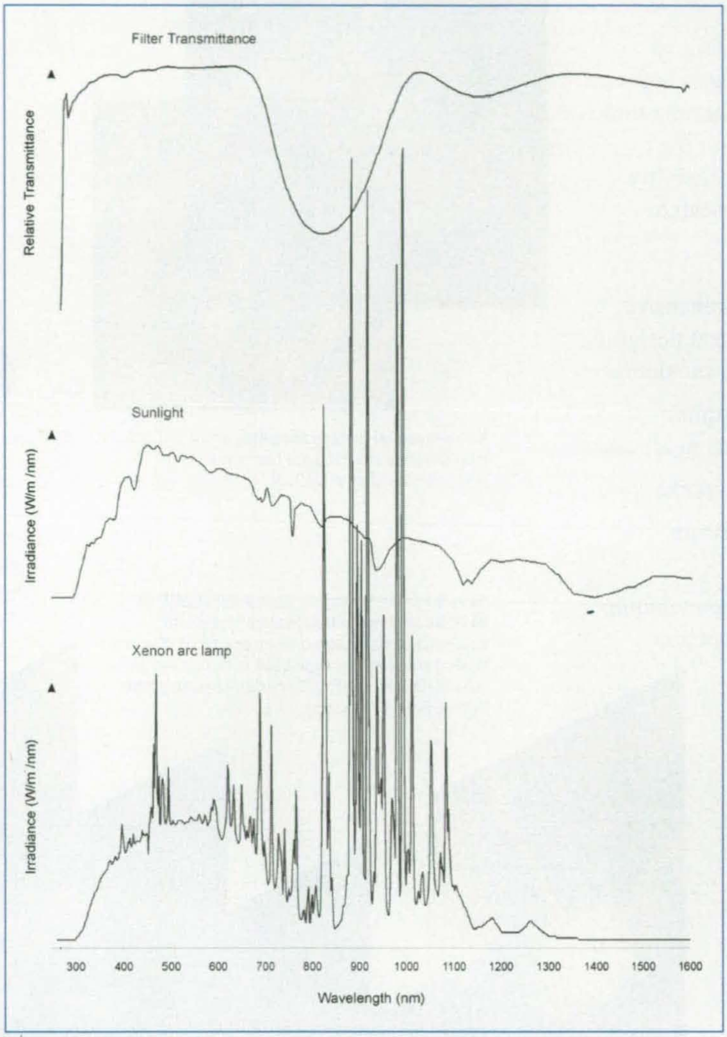

Figure 2. Xenon arc lamp output versus solar radiation spectrum.

Accurate Solar Simulation

In order for laboratory weathering to simulate accurately the effects of real-world exposure, it is essential that the output spectrum of the light source closely match the solar spectrum. The xenon arc lamp source approximates solar radiation well; however, its output does contain some intense spectral lines in the IR and also extends deeper into the UV than the sun does (Figure 2). The IR spikes become particularly problematic during accelerated testing—greater than one sun exposure levels—because they produce excessive product heating.

Historically, absorptive glass filters have been the solution for eliminating the unwanted UV and IR portions of the xenon arc lamp spectrum. IR absorption filters, however, are notoriously unstable in the critical UV, and significant changes in UV transmission challenge efforts to achieve repeatability and reproducibility. Thin-film coatings are inherently more stable, and can also be designed to block the IR spikes in the xenon lamp output more precisely.

In the case of the Atlas Ci4000 Weather-Ometer, however, the filters are in the form of long concentric cylindrical tubes that surround the lamp. Water is flowed in through the inner tube and back out through the outer tube to cool the lamp. Thus, a thin-film coating for this application must be deposited on a small-radius tube and also be capable of surviving both high flux levels and direct exposure to the continual abrasive flow of cooling water.

Traditional evaporative coating technology cannot meet these demands for a number of reasons. First, it is difficult to uniformly coat the entire surface of highly curved parts using evaporation methods. More importantly, this type of film is relatively porous, and a porous film has poor resistance to heat and mechanical wear, and also tends to absorb water, causing a shift in its spectral characteristics.

Sputtering is an alternative coating method that provides denser films and also enables uniform deposition on highly curved parts. Sputtering is conducted in a chamber filled with an inert gas at low pressure. Targets of various conductive materials are placed around the periphery of the chamber. A high voltage is applied to the targets, ionizing the gas around them to form a plasma. These ions are then accelerated into the target, causing atoms to sputter off. The sputtered atoms fill the chamber, and some are deposited on the surfaces of the optics. The low-pressure gas randomizes the movement of the sputtered atoms, leading to uniform deposition on all surfaces regardless of their orientation relative to the material source. Furthermore, the high energy of the sputtered atoms produces coatings that are inherently denser than is achieved through evaporation.

If oxygen is introduced into the machine during sputtering, it will react with the atoms of the material to produce oxides. This process, called reactive sputtering, yields coatings with even better mechanical and thermal characteristics. Recently, Deposition Sciences Inc. has developed a new approach to reactive sputtering called the MicroDyn® process. In MicroDyn, sputtering is augmented by a microwave plasma that forms a wider range of oxygen species (ozone, etc.) to enhance the reactive process. The net result is faster, more efficient deposition, with greater control and variation of the deposited material's refractive index.

Using MicroDyn sputtering, it has been possible to produce a filter that supplies the necessary spectral characteristics, while delivering sufficient mechanical density to withstand prolonged exposure to water, heat, and high flux levels. Specifically, a multilayer, broad-bandpass filter with a cut-on deep in the UV and a cut-off in the IR is deposited on the outside diameter of the inner tube. The cut-off of the filter is placed to provide the precise attenuation of IR wavelengths required; the UV cut-on is placed at a wavelength much lower than required. The outer tube is then fabricated from sharp cut-on absorptive glass, which only transmits above the necessary UV wavelength, but has relatively low IR absorption for maximum stability. This arrangement enables the overall transmission to be optimized on both the long- and short-wavelength ends of the spectrum simultaneously.

Laboratory weathering enables manufacturers in a broad range of industries to improve their products' durability and lifetime. Recent developments in coating technology have now enabled weathering systems with both improved solar accuracy and greater reliability.

The authors of this article are Robert Crase, lighting operations manager of Deposition Sciences Inc., and Kurt P. Scott, general manager of laboratories and calibration services for Atlas Electric Devices. For further information, contact Deposition Sciences at 386 Tesconi Court, Santa Rosa, CA 95401; (707) 573-6785; fax (707) 579-0731; e-mail: bob.crase@depsci.com; www.heatbuster.com; or Atlas Electric Devices at 4114 N. Ravenswood Ave., Chicago, IL 60615; (773) 327-4520; fax: (773) 327-5787; e-mail: kscott@atlas-mts.com.

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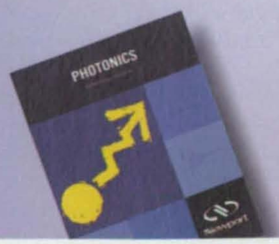

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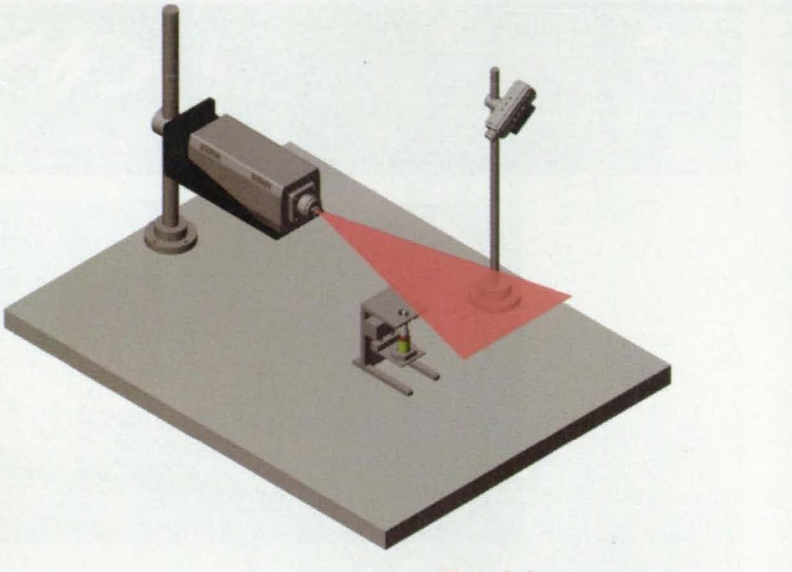

Figure 1. Spray-pattern test setup showing the horizontal laser light sheet, camera, and nasal-spray pump actuator.

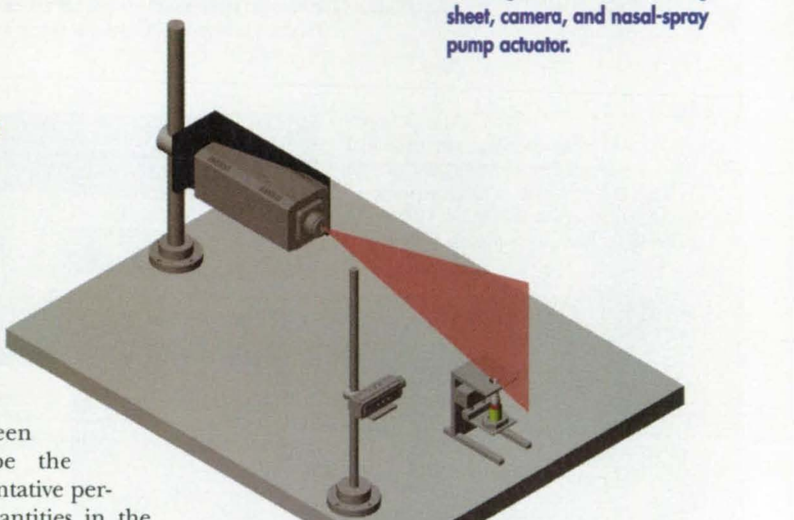

Figure 2. Spray geometry test setup showing the vertical laser sheet, camera, and nasal-spray pump activator.

Image Therm Engineering of Waltham, MA, has developed a state-of-the-art nonintrusive nasal-inhaler spray characterization system. The system design included a Kodak high-speed digital camera and a Lasiris diode laser sheet generator. The analysis and processing software of the system was fully implemented using LabVIEW and IMAQ Vision from National Instruments of Austin, TX. SprayVIEW is currently being used as a research and development tool for current and pending nasal-spray-based medications at Muro Pharmaceutical of Tewkesbury, MA, while Image Therm seeks FDA approval and patents for the system's novel measurement and analysis techniques.

The fluid-dynamic characterization of the aerosol spray emitted by nasal inhalers is crucial in determining the overall performance of the inhaler as a medicinal delivery system to people suffering from various respiratory ailments. Thorough characterization of the spray's geometry has been found to be the best indicator of the overall performance of most nasal inhalers. In particular, measurements of the spray's divergence angle as it exits the inhaler, the spray's cross-sectional ellipticity and uniformity, and the time evolution of the developing spray have been found to be the most representative performance quantities in the characterization of an inhaler design.

These measurements are typically used to optimally match the spray pump's performance characteristics with the fluid properties of the liquid medicine solution, resulting in a more cost-effective and efficient product design. But accurate, reliable, and easy-to-use protocols and a system for nasal spray characterization do not exist for these inhalers. These needs were the motivation for this work.

TLC-Plate Testing Technique

The nasal spray testing standard in use today at many pharmaceutical companies involves firing the spray pump at a solid, thin-layer chromatography (TLC) plate. This plate is positioned at a fixed height above the end of the pump's tip. Spray pattern analysis is done by first exposing the particle-covered plate to UV radiation, causing its coating to fluoresce and helping to highlight the spray pattern. Marking instruments and mechanical calipers are then used to draw and measure an outline of the deposited pattern on the plate. Measurements of the pattern's ellipticity in terms of major and minor diameters are recorded.

Experience has revealed many problems with this technique, including:

- Radical changes to the fluid dynamics of the spray caused by the presence of the TLC plate;
- Flow complications induced by the large amount of spray particles that bounce off the plate;
- Operator error, causing inaccurate measurements of the spray pattern; and
- Lack of support for spray geometry measurements.

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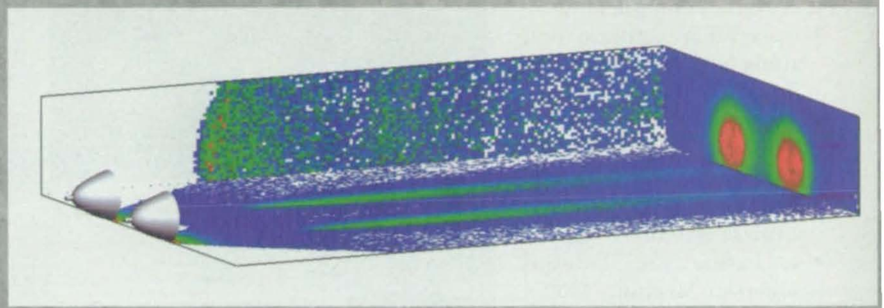
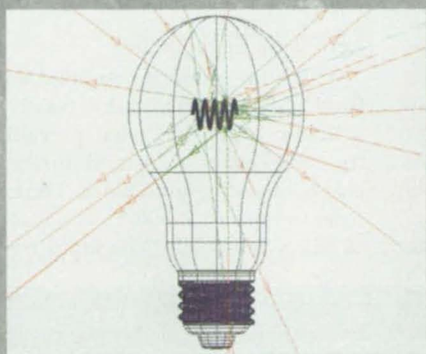
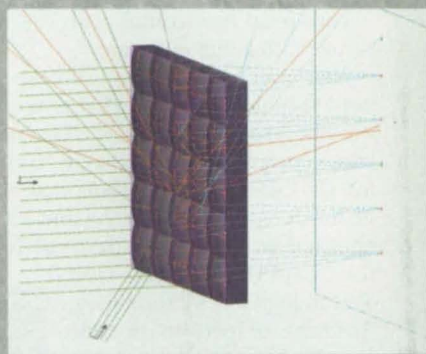
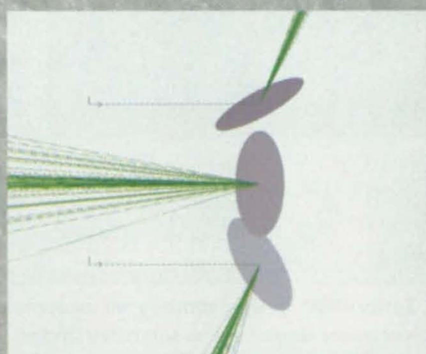


False color irradiance distributions are viewed anywhere "in place" on detectors of arbitrary shape.





Complex objects may be imported, like this IGES light bulb. Other objects, such as this lenslet array, are generated within OptiCAD.



BSDF/BRDF measured scattering data may be placed on any surface for accurate modeling of scattered light.

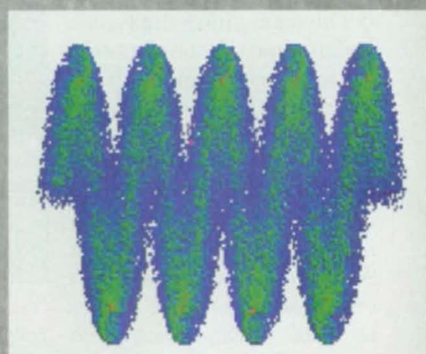


Image of a helical light source ray traced in OptiCAD. Light sources include parametric models, user defined, or tabulated ray data.

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Hardware and System Design

A thorough search of existing technology that could be used or adapted for this system was conducted at the outset of the project. The team finally decided on a hybrid design consisting of a combination of off-the-shelf and custom-made components. The system's basic components are:

- SprayVIEW software built using National Instruments' LabVIEW and IMAQ Vision software;
- a Kodak (San Diego, CA) SR-500 MotionCorder Analyzer high-speed digital camera system;
- a Lasiris (St. Laurent, Quebec) Magnum 4000 4-W laser diode sheet generator operating at 810 nm;
- an InnovaSystems (Pennsauken, NJ) pneumatically controlled mechanical actuator with a digital trigger.

National Instruments' software was used to build the SprayVIEW system software because it provided the best mix of image processing functionality and user interface development tools that would be needed to implement the final custom application. In addition, the SCSI Toolkit for LabVIEW from Icon Technologies of Victoria Park, Australia helped to provide seamless integration for downloading the digital images from the Kodak SR-500 into the SprayVIEW system.

The team chose the Kodak digital camera system because it has a programmable framing rate from 30 to 500 fps at resolutions up to 512 x 480 pixels with 256 grayscales (8-bit). In addition, it has fast on-board memory that allows reliable image captures and a SCSI interface bus for direct downloading of these images to the custom-developed SprayVIEW analysis software running on the host computer.

The researchers selected the Lasiris laser sheet generator because it operates in a continuous mode, produces a thin sheet of laser light directly, and favorably matched the spectral response characteristics of the Kodak camera for adequate illumination of the spray particles.

Since the duration of a single pumping of the spray is on the order of one second, it is crucial to have accurate synchronization between the spray pump actuator and the camera. The InnovaSystems nasal spray pump actuator was chosen because it is standard equipment at many pharmaceutical companies and could be used to trigger the camera accurately when the spray pump is fired.

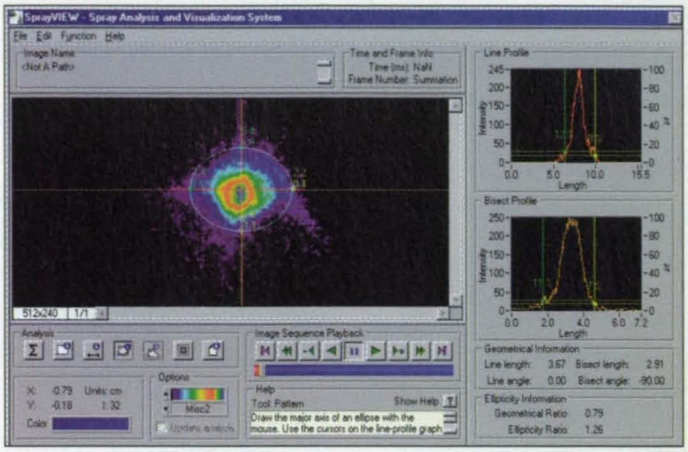


Figure 3. **SprayVIEW spray-pattern measurement tools showing spray ellipticity on the summary image.**

Setting up the System

The spray pump is first filled with test fluid and inserted into the mouth of the actuator, which has been precalibrated for compression force and duration per company testing guidelines. The camera is set to capture at 500 fps at a resolution of 512 x 240 pixels. The input trigger is armed and set to wait for the actuator to fire. The laser is turned on and its light sheet is focused to a thickness of approximately 1 mm when it illuminates the plane of spray particles.

In this configuration, the laser is positioned so that it illuminates a predetermined axial cross section of the spray directly downstream of the spray pump, as shown in Figure 1. The camera is positioned so that it can view the spray pattern from above at angle slightly off-axis to prevent the spray particles from directly impinging on the camera and lens. A calibration target is then temporarily placed in the plane of the laser sheet, and the camera lens is adjusted until the target comes into focus. An image of the focused target is captured with the camera and downloaded to the computer. This target image is used as a basis for calibrating the physical coordinate system of the spray-pattern images and to perform the necessary perspective correction to the images to account for the off-axis viewing angle.

The target image is then removed from the scene, and the trigger is fired on the actuator, causing the camera to start capturing the time-evolving images of the spray pattern. This takes about two seconds. When completed, the images are downloaded from the camera into the SprayVIEW system.

In this configuration, the laser is positioned so that it illuminates a plane of particles parallel to the flow direction along the centerline of the spray, as shown in Figure 2. The camera is positioned perpendicular to the plane of the laser light's sheet. As in the spray pattern test, the calibration target is temporarily placed in the plane of the sheet and the camera lens adjusted until the target comes into focus. Since in this case the camera views the scene normally, no perspective correction is necessary, so the target image is used solely for calibrating the physical coordinate system of the images of the spray geometry. Again, the target image is removed from the scene, the actuator trigger is fired, and the acquired images are downloaded from the camera into the SprayVIEW system.

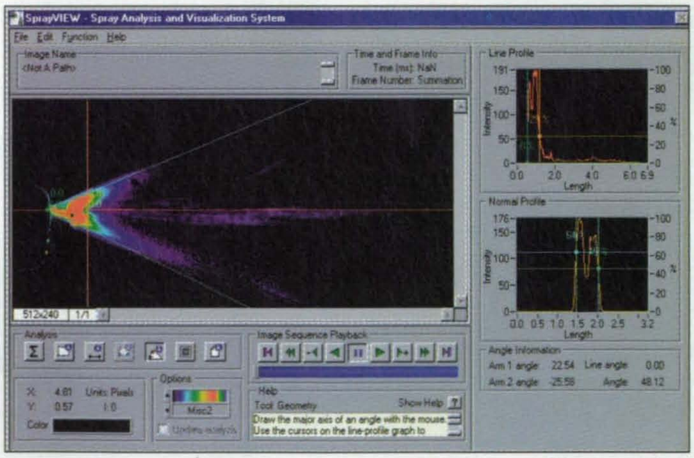
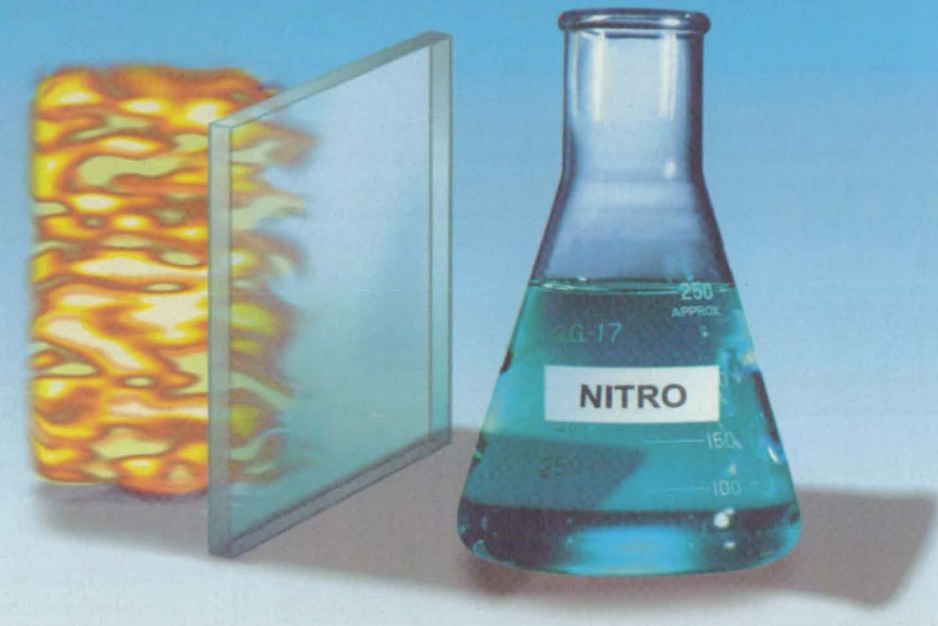


Figure 4. **SprayVIEW spray-geometry measurement tools showing spray divergence angle on the summary image.**

Image Processing and Analysis

The SprayVIEW software was designed specifically to combine powerful image processing and analysis functionality with an intuitive and easy-to-use interface for detailed study of spray images by technicians and scientists alike. The software's VCR-like controls and variety of color palettes allow a user to visualize the details and development of the time-evolution of the spray images.

Our Hot Mirrors clearly have explosive advantages.



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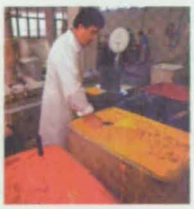

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The time-average or summation tool allows a user-selectable range of spray images to be combined to simulate the trajectory of the individual particles in the spray. This key feature allows the 200+ valid images from a typical test to be represented in one image that can be used for measurements of the spray's uniformity, ellilpticity, and divergence angle, for example. The summary image is also the closest representative of the TLC-plate technique, and this pseudo-backward compatibility forms a key requirement for FDA approval of the system.

Measuring Pattern and Geometry

Spray pattern images are analyzed and processed using the pattern tools. These tools allow a user to specify the major and minor axes of an elliptical pattern template on the summation image. The axis specification is accomplished using interactive cursors that are dynamically linked to line profiles of particle intensity along the axes in absolute and percentage units. The user can adjust the cursors until the most representative elliptical pattern has been specified based on the intensity profiles and computed measurements of the ellipticity ratio, as shown in Figure 3.

Once this elliptical template has been specified, the VCR controls can be used to play back the images in the time-evolution of the spray while simultaneously displaying an overlay of the template. This feature allows a user to visualize the time-evolution of the particle distribution and dynamically compare it to the time-averaged pattern of the particles in a very intuitive manner.

Spray geometry images are analyzed and processed using the geometry tools. These tools allow a user to specify the vertex and included angle of a set of two intersecting orthogonal lines on the summation image. The line specification is accomplished using interactive cursors that are dynamically linked to line profiles of particle intensity along the lines in absolute and percentage units. The user can adjust the cursors until the most representative line-pattern template has been specified based on the intensity profiles and computed measurements of the divergence angle, as shown in Figure 4. Once again, this line-pattern template can be simultaneously overlaid on the time-evolving images and played back using the VCR controls for comparison purposes.

Results and Summary

Muro Pharmaceutical and Image Therm Engineering successfully combined their knowledge and experience with nasal-spray drug development, fluid mechanics, high-speed imaging and image processing software to develop the novel SprayVIEW spray characterization system. It allows spray-based drug developers to characterize the time-evolution, cross-sectional ellipticity, and divergence angle of spray patterns quickly and effectively. The system's nonintrusive optical-based design provides significantly improved measurement performance over the currently accepted TLC-plate-based testing technique. The highly modular hardware and software implementation of the system allows easy customization to meet the needs of a variety of spray-testing applications both in R&D and production environments.

For more information, contact the authors of this article, Dino J. Farina, President, and Socratis Kalogrianitis, Software Designer, at Image Therm Engineering, 159 Summer St., Suite 2R, Waltham, MA 02452; (781) 893-7793; e-mail: farina@imagetherm.com.

Photonics West

Showcasing the Power of Light for the New Millennium

Kicking off the new millennium, SPIE's Photonics West technical symposia and exhibition will fill the San Jose (CA) Convention Center January 22-28. Better than 12,000 are expected to attend from all over the world: 5000 technical attendees, 4000 for the exhibits only, and 3000 exhibitor representatives. Companies displaying products in the exhibit hall, which is completely sold out, number around 550. Eighty-five conferences are scheduled, making up four symposia: BiOS 2000, the International Biomedical Optics Symposium; Lase 2000, concentrating on High-Power Lasers and Applications; Optoelectronics 2000, featuring Integrated Optoelectronic Devices; and Electronic Imaging 2000, centering on its Science and Technology.

The opening shot is what SPIE is calling "Saturday Night Hot Topics" on January 22. From 7:30 to 9 pm, a group of conference chairs and other presenters at BiOS talk about leading developments in the application of photonics to medicine. Other special events take place throughout the week. On Monday from 2-5 pm a working session will consider the new draft standard on optical glass that will replace MIL-G-1748. From 7-9 pm a technical group meeting on research, engineering, and applications of holography takes place, as does a workshop called "Transitioning Optical Coherence Tomography to Industry and Health Care."

Tuesday through Thursday sees two-hour (8-10 am) workshops on the future of optoelectronic markets, sponsored by the Optoelectronics Industry Development Association: Optical Communications (Jan. 25), Electronic Imaging (Jan. 26) and Defense Applications (Jan. 27). A technical group meeting on Wednesday (4-6 pm) centers on Electronic Imaging, and two on Thursday on High-Speed Photography, Videography, and Photonics (12-1:50 pm) and Laser Communications (7:30-9 pm).

BiOS 2000 focuses on several biomedical programs: Clinical Applications, Clinical Instrumentation, Tissue Science and Engineering, Optical Diagnostic Technologies, and Functional Imaging and Biomolecular Analysis. Among the subjects treated are diagnostic and therapeutic cardiovascular interventions; innovations in breast cancer diagnosis and minimally invasive therapy, including laser-interstitial thermotherapy; optical methods for tumor treatment and detection, including photodynamic therapy; and biomedical applications of free-electron lasers. Micro- and nanotechnology for biomedical and environmental applications is a highlight of the Clinical Instrumentation conference, which also includes a Critical Review called "Matching the Energy Source to the Clinical Need." Critical Reviews convene a group of invited recognized experts, each of whom presents an extended invited paper on his or her specific field. The collection of presentations is intended to be an authoritative overview of the technology. Biomedical spectroscopy, vibrational spectroscopy, and other novel techniques are a key focus of the Optical Diagnostic Technologies conference.

Laser Science's new pulsed μ-TEA carbon dioxide laser is among the products that will be demonstrated at Photonics West's Product Forums late this month.

Lase 2000, drawing a bead on high-power lasers and applications, has two programs: Laser Engineering and MicroEngineering/Manufacturing. In the first, a Critical Review on novel materials and crystal-growth techniques for nonlinear optical devices is followed by a conference on nonlinear materials, devices, and applications. Other conferences include solid-state lasers, laser resonators, gas and chemical lasers and intense beam applications, high-power electrical lasers and beam control, and free-space laser communication. In the second, laser applications in microelectronic and optoelectronic manufacturing are stressed, along with laser plasma generation and diagnostics.

Optoelectronics 2000, encompassing Integrated Optoelectronic Devices, has three programs: Optoelectronics Materials and Devices, Semiconductor Lasers and Photodetectors, and Hybrid and Monolithic Optoelectronic Integrated Circuits (OEICs). These will be introduced by a series of plenary presentations. On Monday at 8:30 am, the subjects are "Atom Interferometry in Materials Research" and "Two-Dimensional Photonic Bandgap Lasers and Waveguides." Following at 9:15 are "Progress and Commercialization of InGaN-based Violet/Blue Laser Diodes" by a representative of the Nichia Corp. of Japan, and "Plastic Optoelectronics." On Tuesday at 8:00 am the subject is "Soliton Telecommunications." Following at 8:40 is "Polymers in Integrated Photonics—Applications Where They Have the Advantage," and at 9:20 am "Innovative Photonic Components Technology for Communications Systems."

In the first of Optoelectronics 2000's programs there are presentations on micro- and nano-photonic materials and devices, the research, manufacturing, and applications of light-emitting diodes, organic photonics materials and devices, rare-earth-doped materials and devices, and sol gel optics, among others. The second program includes papers on laser diodes in industrial measurement, imaging, and sensors applications, vertical-cavity surface-emitting lasers, and photodetector materials and devices, among others. In the third, there are presentations on WDM and photonic switching devices for network applications, diffractive/holographic technologies and spatial light modulators, and photonics packaging and integration, among others.

Concurrent with these programs, running from Sunday, Jan. 23, through

Friday, Jan. 28, there are 87 courses and 6 workshops in the Continuing Education Program, for which CEUs—Continuing Education Units, a nationally recognized unit of measure—are awarded to registrants who complete the courses.

A special pavilion will be devoted to the Electronic Imaging 2000 symposium, sponsored by SPIE and the Society for Imaging Science and Technology. The symposium's 26 conferences are organized into eight programs: 2D Displays; 3D Capture and Display; Electronic Imaging Systems and Image Processing Methods; Document Imaging, Sensor, and Camera Systems; Image Sequence and Data Analysis; Multimedia Processing and Applications; Optical Security and Anti-counterfeiting; and Image and Video Communications and Processing. The sessions Tuesday through Thursday will be launched each day by a plenary presentation: "Evolution of Digital Photography" (Tues.), "The Co-evolution of Humans and Computers" (Wed.), and "Multispectral Imaging: Fundamentals and Applications" (Thurs.). Individual conferences deal with such topics as projection displays; liquid crystal materials, devices, and flat panel displays; holographic materials; stereoscopic displays and applications; applications of artificial neural networks in image processing; sensors, cameras, and systems for scientific/industrial applications; Internet imaging; security and watermarking of multimedia contents; and optical security and counterfeit deterrence techniques.

In recent years SPIE has introduced a talked-about series of Product Forums, which take place in the areas called "Town Squares" set aside in the exhibit hall. In a Product Forum, an exhibiting company demonstrates new and successful products in half-hour question-and-answer sessions. This year, in the Laser Town Square, Laser Science introduces its µ-TEA carbon dioxide laser (10:30 am Tuesday); QED Technologies demonstrates the innovative polishing technique for high-precision plano, spherical, and aspherical optics using magnetorheological finishing (11:30 am Wednesday); the market research firm ElectroniCast presents an analysis and 10-year forecast of the global consumption of optical fiber, planar waveguide, and free-space signal and interconnect components (12:30 pm Tuesday); and New Focus shows real-time manufacturing testing using a swept wavelength laser (2:30 pm Tuesday), among other events.

In the Photonics Town Square, Arris International presents a Product Forum on new materials for the new millennium (12:30 pm Tuesday); Breault Research Organization shows off ASAP 6.6, the latest version of its well-known optical modeling and analysis software (10:30 am Wednesday); and OFC's Diamond Turning Division demonstrates the efficiencies obtained using diamond-turning optical systems having comachined datums for ease of alignment (12:30 pm Wednesday), among other sessions.

In the Electronic Imaging Town Square, GF Measurement demonstrates how the digital projection of light by digital micromirror devices invented by Texas Instruments (Dallas) opens up new possibilities in optical data projection (10:30 am Tuesday); Kodak Microelectronics Division shows its BluePlus line of high-performance CCD image sensors (11:30 Tuesday); and Foresight Imaging stages a demonstration of its automatic configuration software Auto-SYNC, among other sessions.

Symposium registration fees include admission to all conference sessions, either one or two proceedings volumes, one abstract book, plenaries, panels, poster sessions, receptions, coffee breaks, and exhibits admission. For more information, or to register, contact SPIE at (360) 676-3290; fax: (360) 647-1445; e-mail: pw@spie.org; web: www.spie.org/info/pw/.

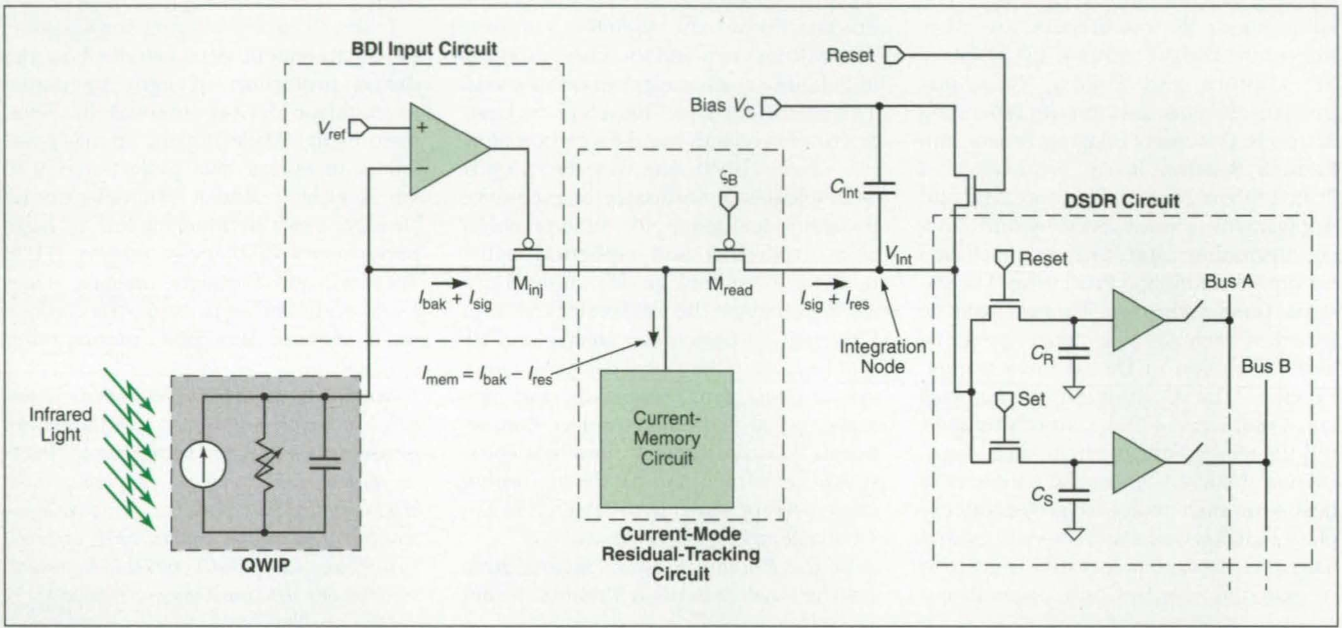
Current-Mode Dark-Level Subtraction in LWIR Imaging

This circuit offers high dynamic range and low noise.

NASA's Jet Propulsion Laboratory, Pasadena, California

A complementary metal oxide/semiconductor (CMOS) focal-plane readout circuit for an imaging array of long-wavelength infrared (LWIR) photodetectors effects in-pixel current-mode subtraction of the dark-level component of each photodetector output. The dark-level signal is subtracted before the signal reaches the integration node. Consequently, for each pixel in the array, the readout noise is minimized and the net gain and dynamic range are maximized.

This readout circuit was designed to overcome two major obstacles to the



Each Unit Cell of the Readout Circuit effects in-pixel current-mode subtraction of the dark-level component of each photodetector output prior to integration.

achievement of high performance in LWIR arrays used in imaging or spectroscopy under common operating conditions:

- Leakage in the photodetectors and/or high scene background gives rise to a large background signal, making it necessary for the focal-plane circuitry to handle of the order of several billion electron charges per pixel per readout cycle. Ordinarily, prohibitively large capacitors would be needed to handle such large amounts of charge, and the handling of large amounts of charge would introduce additional noise.
- Often, there is poor signal-to-background contrast in the sense that the signal of interest is of the order of only 10^{-4} or 10^{-3} times the background signal.

The present circuit operates in a readout cycle in which a blanking or calibration phase alternates with an imaging phase. During the blanking phase, a current-memory circuit memorizes the background current for use in predicting the background current for the subsequent imaging phase. During the imaging phase, the current-memory circuit acts as a high-impedance current source that generates the predicted background current,

which is subtracted from the photodetector output current to obtain the signal current of interest. This signal current is coupled to external circuitry through low-noise circuitry, and an innovative biasing scheme improves low-noise performance.

A prototype of the circuit comprises a bilinear array of 2 x 132 multiplexers. Each unit cell (see figure) contains a LWIR photodetector [more specifically, a quantum-well infrared photodetector (QWIP)], a buffered-direct-injection (BDI) input circuit, a current-mode pedestal-subtracting circuit, and a voltage-mode double-sampled differential readout (DSDR) circuit. The BDI input circuit provides the stable bias needed for operation of the QWIP, plus a high input impedance that enables high quantum efficiency. The current-mode pedestal-subtracting circuit comprises a cascode current-memory circuit, and an isolation field-effect transistor (FET) denoted "M_{read}."

During the blanking phase, the current I_{bak} flowing through the QWIP consists of the detector dark current (usually the dominant component, of the order of a few hundred nanoamperes) plus a smaller current due to scene and instrument background. I_{bak} is the pedestal signal that one seeks to subtract. Ideally, once the current-memory circuit has memorized I_{bak}, it should be able to generate $I_{mem} = I_{bak}$. However, because of imperfections in the circuit, I_{mem} and I_{bak} differ by a small amount: $I_{mem} = I_{bak} - I_{res}$, where I_{res} is denoted the error current. The pedestal signal due to I_{res} cannot be eliminated in the current-mode subtraction; therefore, it is estimated in the voltage mode by integrating the error current onto capacitor C_R in the DSDR circuit. This completes the memorization of the background signal.

During the imaging phase, the current through the QWIP rises above I_{bak} by an amount I_{sig}, which represents the infrared signal to be measured. Thus, the current sent to the integration node during the imaging phase equals $I_{sig}+I_{res}$. Once the imaging phase has been completed, the voltage V_{int} obtained by integrating $I_{sig}+I_{res}$ onto integration capacitor C_{int} is sampled on capacitor C_S in the DSDR circuit. As a result, the difference between the potentials on C_S and C_R is almost exactly proportional to I_{sig}, with background suppressed by factor of more than 10^4.

The gate of M_{read} is dc-biased with a voltage, such that during the blanking phase, the current-memory potential shuts M_{read} off, while during the imaging phase, the source of M_{read} charges up to a potential that enables the injection of current into the integration node. This biasing scheme makes it possible for the circuit to operate without need to apply a pulse signal ϕ_{read} to M_{read}. In so doing, the biasing scheme helps to keep noise low by preventing the injection of switching noise into a sensitive node.

The circuit provides for noise-limited measurement of signals 85 dB below the dark level. It is designed to operate with low power dissipation and high linearity, and is capable of handling pedestal currents up to 300 nA. Accurate subtraction of background charge makes possible a charge-handling capacity of >5 x 10^9 electron charges per pixel.

This work was done by Bedabrata Pain, Guang Yang, Chao Sun, Timothy Shaw, and Chris Wrigley of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

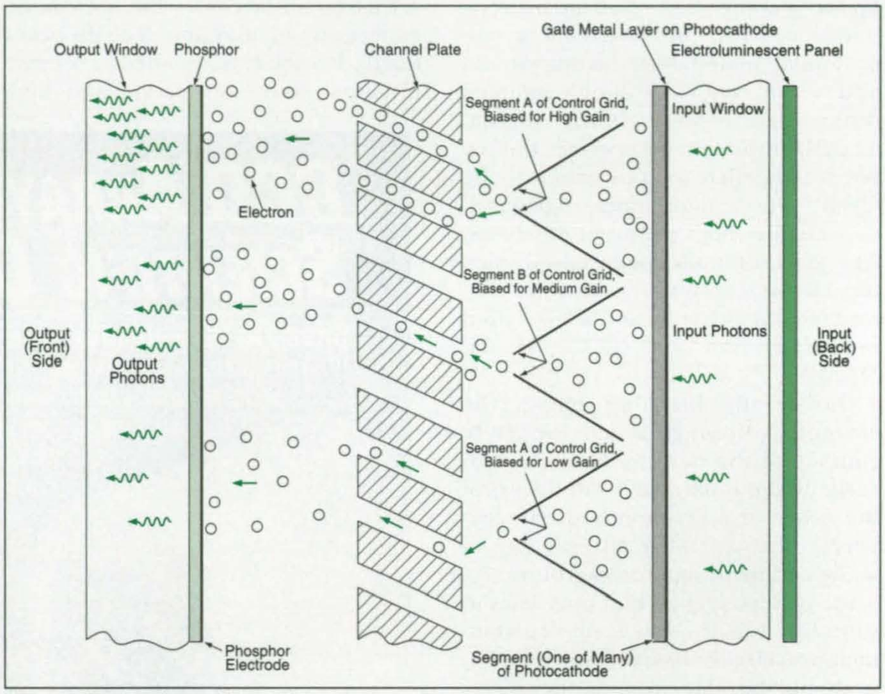
NPO-20486

Segmented-Cold-Cathode Display Panels

In comparison with CRTs, these panels could be much wider and thinner.

Goddard Space Flight Center, Greenbelt, Maryland

Display panels based largely on the principles of proximity-focused image-intensifier tubes have been proposed as alternatives to cathode-ray tubes (CRTs) and other conventional devices for wide displays. A panel of the proposed type would afford the high brightness and wide viewing angle (almost 180°) of a CRT, but it could readily be made much wider than the maximum dimension [50 in. (127 cm) diagonal] of currently available CRTs. The thickness of the



This **Display Panel** would include a proximity-focused channel-plate image intensifier with a segmented control grid and a segmented photocathode illuminated by an electroluminescent panel.

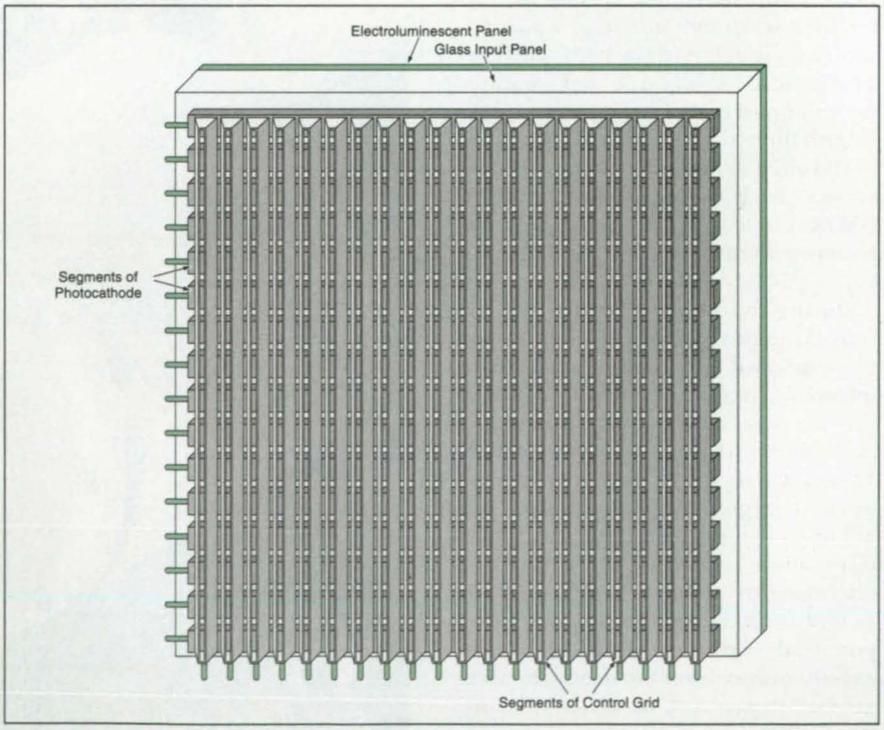


Figure 2. **Pixels Would Be Defined** by intersections of photocathode and control-grid segments. The photocathode segments would be activated sequentially to turn on rows of pixels sequentially. The brightness of each pixel in a row during its "on" period would be controlled via the voltage applied to the corresponding control-grid segment.

panel [<4 in. (<10.2 cm)] would be much less than the depth of a typical CRT. Moreover, unlike a CRT, the panel would not introduce any geometric distortion into the displayed image because the image geometry would be established by a pixel structure within the panel.

Partly ignoring the two-dimensional aspect of the display for the moment, some basic physical aspects of the panel can be explained by reference to Figure 1. An electroluminescent panel on the back side would supply photons for excitation of a segmented photocathode. The photons would travel through an input window and through a transparent gate metal layer into the photocathode segment. The gate of the photocathode segment would be biased at about –20 V, relative to a channel plate, to encourage photoemission of electrons and force the emitted electrons toward the channel plate. A control grid based on the same principle as that of a control grid in a triode vacuum tube would be variably biased (probably to a potential between –10 and –30 V) to control the local brightness of the display by allowing more or fewer electrons to pass to the channel plate.

The channel plate would be about 2 cm thick, and the pores in the channel plate would be about 0.5 mm wide. The output side of the channel plate would be biased to a maximum potential of about 1 kV relative to the input side, so that the number of electrons striking the input pores of the channel plate would be multiplied to a large magnitude. The resulting cloud of electrons emerging from each pore in the channel plate would encounter an electric field that would accelerate the electrons toward a phosphor. The electric field would be provided by biasing a phosphor electrode at about 22 kV relative to the output side of the channel plate.

The phosphor electrode would be about 1,000 Å thick — thick enough to be opaque to light coming from behind but thin enough to pass electrons with kinetic energy >2 keV. Thus, the electrons would lose about 2 keV of kinetic energy traversing the phosphor electrode and would deposit the remainder of their kinetic energy in the phosphor, causing the phosphor to glow. The local intensity of the glow would depend on the bias applied to the local control grid. A multicolor display could be implemented by placing groups of red, green, and blue phosphors in registration with groups of three control grids in red/green/blue sequence. Thus, a multicolor display would contain three times the number of control grids of a monochrome display.

The two-dimensional aspect of the display can be explained by reference to Figure 2. A pixel would be defined by an intersection between one of the vertical control-grid segments and one of the horizontal photocathode segments. The minimum pixel size would be of the order of 1 mm; although this size is too large for the desired resolution in a small display that would ordinarily be implemented in a liquid-crystal display unit, it is an appropriate size for a wide-screen television or similar display. One of the advantages of larger pixels is greater ease of fabrication.

During operation, one photocathode segment (defining a row of pixels) would be biased to promote photoemission while the other photocathode segments would be biased to inhibit photoemission. During a frame period, rows of pixels would thus be turned on sequentially, the sequence repeating for each subsequent frame period. During the "on" period for each row, each control-grid segment would be biased to the potential needed to obtain the desired brightness in the pixel lying at the intersection of the control-grid segment and the activated photocathode segment. An alternate version of this display panel replaces the channel plate with a uniform grid mesh. This mesh is biased to the same level as the channel-plate input side. Although this version of the display will not be as bright

as the channel-plate version, existing photocathode materials support current densities that will allow output light levels near that of conventional CRT's without using a channel-plate electron multiplier. Also, this alternate version is substantially easier to fabricate.

This work was done by Leslie James Payne of **Goddard Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center; (301) 286-7351. Refer to GSC-13708.

Method of Measuring Encircled Energy for Imaging Optics

Micromachined apertures are precisely, concentrically interchanged in focal planes.

Goddard Space Flight Center, Greenbelt, Maryland

The radial distribution of energy within an image, called encircled energy, is a classical measure of the quality of the optical system producing that image. An improved method for measuring encircled or enclosed energy for imaging optical systems makes use of precisely micromachined apertures which are positioned with great accuracy at the center of an image.

The technique is an improved solution to the problem of measuring radiant fluxes passing through a sequence of round or square holes of progressively increasing size, all centered on the same point of interest in a focal plane of the optical system. The sequence of measurements determines the radial distribution of irradiance about the point of interest. This distribution is useful for specifying and characterizing the performance of the optical system; in particular, if the point of interest is the nominal center of the image of a bright point object, then the desired distribution is related in a known way to the point-spread function of the system.

The concept of using progressively wider apertures of identical shape to

measure the radial distribution of irradiance is so straightforward as to seem almost trivial; however, in practice, it has historically proven difficult to implement this concept with the precision needed to characterize the performances of advanced vacuum-ultraviolet and x-ray imaging instruments. The difficulty lies in being able to interchange each aperture exactly concentrically and in focus, especially with a collection of discrete apertures. Alternative methods which involve knife-edge or slit scanning are always indirect approaches to measuring encircled energy and produce somewhat ambiguous results.

The new method affords all of the necessary precision. An opaque mask containing a linear array of identically-shaped but differently-sized apertures has been fabricated by chemical micromachining in a thin, flat silicon substrate. Also fabricated during the micromachining process are a set of binary-coded fiducial marks — one mark for each aperture, located at a known distance well to the side of the aperture. The precision of dimensions and locations of apertures and fiducial marks are of the order of 0.1 to 0.2 μm — commensurate with the state of the art of microlithography. Aperture sizes progress slowly from 1 μm all the way up to 2 mm in both circular and square aperture shapes.

The aperture mask is mounted in front of a photodetector on a translation stage with three mutually orthogonal axes with 0.1-μm position resolution — one for motion perpendicular to the focal plane (focus) and two for motion within the focal plane.

The linear array of apertures is carefully mounted so as to be parallel to the direction of travel of one of the latter motions. The exact position of the selected aperture of interest in the focal plane is sensed by using an optoelectronic apparatus to measure the position of the associated fiducial mark: A lens focuses a magnified image of the backlit fiducial mark onto a small charge-coupled-device (CCD) image detector. The CCD output is digitized and processed to decode the binary pattern (and thereby the selected aperture) and to determine the position of the aperture to within about 0.01 μm.

In preparation for the measurement process, a photodetector wider than the focal spot of interest is positioned just behind the focal plane to intercept the focused light. The largest aperture in the aperture mask is centered approximately on the image, then moved from side to side along both image-plane axes while observing the photodetector output to find the points, corresponding to passage of the aperture edge, beyond which the light is totally blocked. The center of the image is tentatively deemed to lie halfway between the extinction points on the two axes. To locate the center of the image with progressively increasing precision, this procedure is repeated with the next smaller aperture, and so forth down to the smallest aperture. Then a final precise centering operation is performed by searching for the maximum photodetector output or other suitable indication while using the smallest aperture.

Once the center has been located, the encircled-energy measurement begins with the recording of the photodetector response with the smallest aperture in place. Then the responses are recorded with successively wider apertures, using the translation stage and fiducial marks to ensure the concentricity of each successively selected aperture. The photodetector responses thus recorded constitute the desired raw encircled-energy data.

This work was done by Douglas B. Leviton and Sridhar M. Manthripragada of **Goddard Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at*** ***www.nasatech.com*** *under the Physical Sciences category. GSC-13872*

High-Power, Wideband Laser-Diode Transmitter Module

Diffraction-limited operation affords long range.

Goddard Space Flight Center, Greenbelt, Maryland

A prototype compact, rugged optomechanical module contains a high-power, wideband laser-diode transmitter. The laser diode is of a commercial single-quantum-well AlGaAs type. Each laser diode of this type is manufactured for a specific nominal wavelength in the range from 810 to 860 nm; the one in the prototype module lases at a nominal wavelength of 824 nm. The laser diode can be operated to emit continuous-wave power of 150 mW or with amplitude modulation at average and peak powers of 150 and 300 mW, respectively. The power consumption of the entire module in dc operation is 400 mW. The laser diode is mounted on a copper plate, which conducts heat from the laser to a cold plate on which the module is mounted. The cold plate is maintained at a temperature of 15 °C.

A circuit board mounted on the copper plate next to the laser diode incorporates both dc and ac modulation electronics. Also included on the circuit board are a thermistor and a resistive heater for sensing and regulating the temperature of the laser diode. The modulation electronics include a reactive network matching circuit that enables the use of modulation frequencies up to a 3-dB-falloff frequency of 2.5 GHz. The laser diode, circuit board, and copper plate are all epoxied to a block of low-thermal-expansion glass, providing a stable platform from which to collimate and point the laser beam.

The laser diode emits a widely diverging, diffraction-limited, single-spatial-mode beam. A glass etalon in front of the laser provides wavelength-selective feedback and thus enables single-wavelength operation even in the presence of a large modulation signal. A molded glass aspherical lens with a focal length of 2 mm and an aperture diameter of f/1 roughly collimates the diverging laser beam to a divergence of about 0.5 by 1.5 milliradians. The roughly collimated laser beam also passes through a matched pair of lenses comprising a long-focal-length positive and a long-focal-length negative lens; the distance between these two lenses is adjusted to achieve fine adjustment of the collimation of the beam. The divergence achievable with fine adjustment of the collimation is low enough to make the laser beam useful at distances of the order of kilometers.

A pair of wedge prisms is used for fine adjustment of the pointing of the beam. A cubic beam splitter picks off a small fraction of the beam and directs it to another aspherical lens, which focuses this sample of the beam into a single-mode optical fiber for use in monitoring the modulation waveform or as a local-oscillator source for an optical receiver. To reduce the effects of optical feedback from the passive optical components into the laser, a quarter-wave plate is placed immediately after the first aspherical collimating lens, and adjusted such that the polarization of any reflected light passing through is rotated to be orthogonal with the original polarization of the laser. Because the laser has almost no gain for this orthogonal polarization, the reflected light exerts no measurable effect on the laser.

This work was done by Donald M. Cornwell, Jr., and Pamela S. Millar of **Goddard Space Flight Center,** *Daniel X. Hopf of SSAI, and Anthony W. Yu of HSTX. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. GSC-13824*

Software for Processing Data in Particle-Image Velocimetry

This flexible, user-friendly program computes flow velocities from seed-particle images.

John H. Glenn Research Center, Cleveland, Ohio

PIVPROC is a computer program for processing data in particle-image velocimetry (PIV), which is a method of determining a flow velocity field from images of small seed particles that are entrained in the flow and that are illuminated by laser pulses at known intervals of time. PIVPROC creates an interactive computing environment for displaying and processing PIV image data. This environment includes a graphical user interface that provides user-friendly access to the image-data-processing capabilities of the program.

In PIV, a charge-coupled-device (CCD) camera records images that show the positions of the illuminated particles at two or more instants of time; then the image data are processed to extract velocities from the apparent displacements of the particles during the intervals between exposures. The processing involves one or more of three types of data-reduction techniques: autocorrelation, cross-correlation, and particle tracking. Autocorrelation is used to process double-exposure images, whereas cross-correlation and particle-tracking techniques are applied to pairs of single-exposure images.

In correlation processing, an image frame is divided into small subregions, each containing particle images. An auto- or cross-correlation operation is performed in each subregion, wherein the average displacement of the particles results in a displacement peak on a correlation plane. From the location of the displacement peak on the correlation plane and the time between laser pulses, the velocity in the subregion during that time can be computed. By thus processing the image over a regular grid of small subregions, one generates a velocity-vector map.

In particle tracking, displacements of individual particles are identified and used to compute velocities. In a combined correlation/particle-tracking operation, a correlation velocity-vector map is computed, then used as a guide for particle tracking.

The graphical work environment created by PIVPROC helps the user to perform autocorrelation, cross-correlation, and particle tracking operations on PIV image data. The raw PIV image data can be loaded and displayed on the computer screen. The image gain and threshold level can be adjusted by use of dialog boxes. The correlation processing settings are also displayed in dialog boxes. Subregions wherein correlation processing is in progress are displayed in real time, along with the output correlation plane.

PIVPROC employs fuzzy logic for validating detections of correlation peaks and for determining correct particle pairings in particle-tracking operations; fuzzy logic enables the implementation of data-reduction algorithms that mimic or surpass the ability of a human operator to identify the correct particle pairings in the image data. PIVPROC supports the combined use of cross-correlation and particle tracking to obtain high-quality velocity data over a wide range of particle-seeding densities.

The velocity-vector maps generated by processing image data can be displayed, edited manually by use of the computer mouse, printed, and written to files. The data can also be interpolated; the program includes interpolation algorithms that enable the user to transform the spatially randomly sampled data from a particle-tracking operation onto a uniform grid of velocity vectors; the use of a uniform grid facilitates comparison of a velocity field determined by PIV with the corresponding velocity field determined by computational fluid dynamics.

PIVPROC runs in the Windows 95, Windows 98, and Windows NT operating systems. All of the data-processing and image-manipulation routines in PIVPROC are written in FORTRAN. The Microsoft Windows Application Programming Interface (API) functions are used to generate and service the interactive user environment.

This work was done by Mark P. Wernet of **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

LEW-16857

Telescope for Imaging and Laser Communication

Light is transmitted and received through the same objective lens.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature, single-aperture optoelectronic instruments called "multi-function telescopes" are being developed for use in both scientific observations and laser communications aboard microspacecraft that are expected to be launched in the next few years. These instruments could also be adapted to imaging and communication applications on Earth.

As now envisioned, a multi-function telescope would serve as (1) a conventional telescope for scientific imaging, (2) a telescope for celestial navigation, (3) an infrared spectrometer, and (4) a laser communication system. A prototype multi-function telescope called "a combined laser-communication and imager for microspacecraft" (ACLAIM) has been built and tested to demonstrate two of these functions: laser communication and scientific imaging. The prototype instrument was assembled from mostly commercially available parts.

The figure schematically depicts the prototype instrument. All incoming and outgoing light passes through a telephoto mirror camera lens. Within the instrument, there are three partly overlapping optical channels: a receiving channel, a transmitting channel, and a boresight channel. The three channels intersect at a dichroic beam splitter, which makes it possible to use the same path through the telephoto lens for both receiving and transmitting.

The receiving channel extends from the telephoto lens to the beam splitter to an Active-Pixel Sensor (APS). Light to be transmitted is generated by modulating the power supplied to a laser diode equipped with a pigtail optical fiber, and the transmitting channel is considered to extend from the output end of the optical fiber to the beam splitter, then from the beam splitter out through the telephoto lens. The beam splitter exhibits high reflectance at wavelengths from 500 to 900 nm, except in a 40-nm-wide band at the laser wavelength of 670 nm, where it exhibits 70-percent transmittance.

The boresight channel includes a retroreflector, which sends a small portion of the laser beam to the APS . A laser beacon at a distant receiver is also imaged onto the APS. The positions of the spots of light from the beacon and the laser beam are measured and used to compute the angle between the transmitted beam and the line of sight to the beacon.

In the original intended use aboard a spacecraft, the spacecraft would be turned to aim the telescope at an astronomical target of scientific interest and image data would be acquired by use of the APS. The image data would be stored in memory for subsequent transmission to the distant receiver via modulation on the outgoing laser beam.

In preparation for transmitting the image data, the spacecraft and telescope would be turned to bring the beacon at the receiver within the field of view of the telescope. Then a control system would adjust the orientation of the spacecraft and of a fast-response fine-pointing mirror in the instrument, in response to the angle measured as described in the preceding paragraph. The techniques for measuring the angle and aiming the telescope were described in more detail in four previous articles in *NASA Tech Briefs*; "Beam-Steering Subsystem for Laser Communication" (NPO-19069), Vol. 19, No. 6 (June 1995), page 32; "Digital Controller for Laser-Beam-Steering Subsystem" (NPO-19193), Vol. 19, No. 11 (November 1995), page 93; "More About Beam-Steering Subsystem for Laser Communication" (NPO-19381), Vol. 19, No. 11 (November 1995), page 93; and "Image Processing in Laser-Beam-Steering Subsystem" (NPO-19396), Vol. 20, No. 5 (May 1996), page 24.

This work was done by Hamid Hemmati and James Lesh of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

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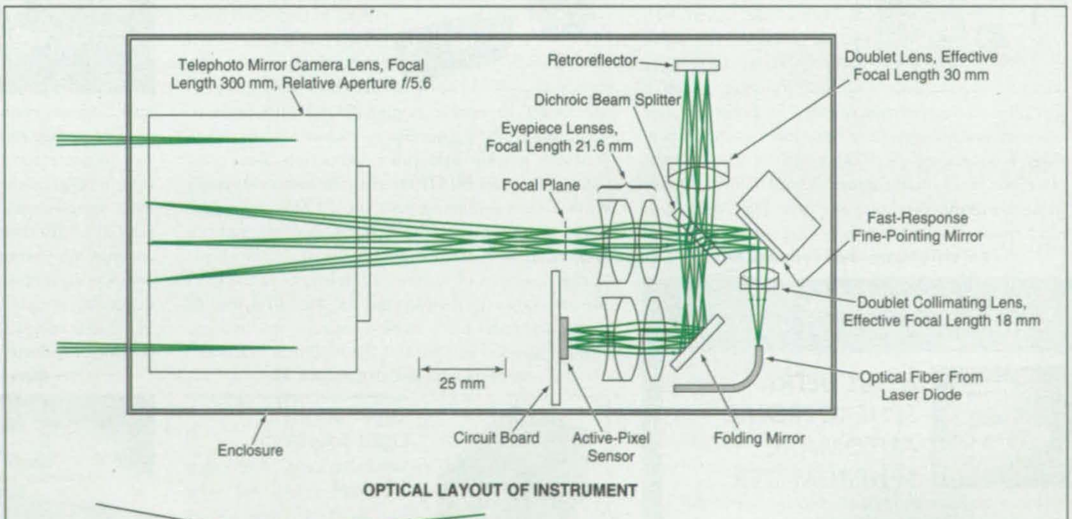
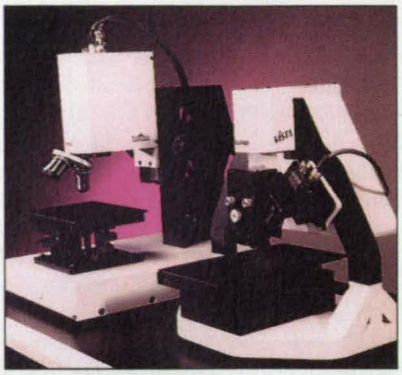


This **Instrument Can Be Used** for both imaging and laser communication. The imaging function is also used to aim the instrument for laser communication.

NEW PRODUCTS

PRODUCT OF THE MONTH



Two Surface Topography Instruments in One

Burleigh Instruments, Fishers, NY, calls its new Gemini surface topography system the first to combine an atomic force microscope (AFM) and an optical profiler in one package. The Gemini includes Burleigh's Vista large-sample AFM and Horizon noncontact optical profiler, providing direct 3D measurements from the millimeter to the angstrom level. The Vista offers contact, AC, phase, and lateral force imaging modes with optional scanning tunneling mode. The Horizon offers the capability to measure areas as large as 2 mm square with a Z range of 100 microns, while also providing vertical resolution on the angstrom level. Thus the Gemini measures topographic features, surface roughness, friction, and compliance.

For More Information Circle No. 745

Digital Laser Doppler Vibrometer

Polytec PI Inc., Auburn, MA, launches its new VDD-650-DA and VDD-660-DA digital laser Doppler vibrometers. According to the company, these devices utilize digital signal acquisition and processing technologies to achieve exceptional displacement accuracy and resolution down to 1 picometer, high linearity, and low harmonic distortion over a very wide vibration frequency range of DC to 2 MHz. The vibrometers can be used in conjunction with almost any of Polytec's optical sensor heads. They include a signal acquisition board for PC-based processing of the Doppler signal and Vibsoft software running under Windows NT for display and processing of frequency-domain and time-domain vibration data.

For More Information Circle No. 746

Flexible Light Pipe System

The Optoelectronics Division of Bivar Inc., Irvine, CA, introduces a flexible light pipe (FLP) series. The new light pipes' flexible tubing, the company says, is clad in flame-retardant 94V-0 UL-rated material, and can extend to reach virtually any LED location on a PCB. The FLP series can carry the full intensity of a surface mount device or through-hole LED up to 100 feet away. Standard lengths range from 3 in. to 48 in. with custom lengths up to 100 ft. The diffusing lens of the series, offered in a variety of color selections, comes frosted clear as standard, with custom colors available.

For More Information Circle No. 747

Laser Interferometer for Optics Industry

Veeco Metrology Group, Tucson, AZ, offers the Wyko™ RTI 4100 laser interferometer, which the company says provides ultraprecise noncontact surface characterization and transmitted wavefront measurements of optical components and assemblies. Veeco calls the instrument one that provides fast, repeatable measurements with absolute accuracy better than $\lambda/200$ P-V and RMS repeatability better than $\lambda/10{,}000$. Measurement can be done on steep surfaces, with greater than 7 waves/mm slope at high magnification. A choice of laser sources and apertures allows the system to be tailored to specific applications.

For More Information Circle No. 748

Laser Displacement Sensors

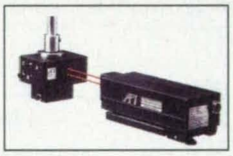
The AR600™ series of line-scan-camera laser displacement sensors from Acuity Research, Menlo Park, CA, come in 11 models with full-scale spans from 0.125 in. with an accuracy of 0.00015 in. up to a span of 50 in. with accuracy of 0.05 in. Acuity calls the devices suitable for use in measurement systems from 0.5 to 80 in. distance; they will operate at up to 1250 samples per second. Many CCD-camera-based sensors require an external control and signal conditioning box or PC card, but the AR600 does not; its sensors are self-contained and NEMA-4/IP-67 sealed for wet and dirty environments. The sensors are designed to be used in electronics, wood, metal, paper, rubber, and food production.

For More Information Circle No. 750

Fiber Optic Illuminator

Stocker & Yale, Salem, NH, makes available the Mille Luce™ Model 1000 fiber optic illuminator, which it says offers a 400-percent increase in lamp life over conventional halogen fiber optic illuminators. It provides a minimum of 1000 hours of shadow-free, glare-free, cool illumination without significant loss in light output, the company says. The Mille Luce has a quick-change positive-locking nosepiece.

For More Information Circle No. 751



System for "Error-Mapping" a CMM

Automated Precision Inc., Gaithersburg, MD, has designed a new laser measuring system specifically to enable manufacturers and users to "error-map" their coordinate measuring machines (CMMs) quickly and more accurately than ever before. The API 6D HP system simultaneously maps six possible positioning errors of a CMM, recording linear measurements with a precision of 0.2 part per million. The six factors include linear displacement in the direction of motion, straightness of travel in the two axes perpendicular to the direction of motion, angular pitch motion, angular yaw motion, and the angular roll around the direction of travel.

For More Information Circle No. 752

Deep-UV Spectrophotometer

Acton Research Corp., Acton, MA, has added the CAMS-507 deep-UV spectrophotometer to its line of optical measurement systems. The unit is designed to provide precise reflectance, absorption, and transmission measurements in the 120-nm to >350-nm wavelength range. According to Acton, the system measures samples with unsurpassed repeatability, including CaF_2, "dry" fused silica, deep-UV optics, thin film coatings, photoresists, and silicon wafers under vacuum or purged conditions. Available with an option for measuring samples at 157 nm or 193 nm under polarized conditions, the CAMS-507 was designed with semiconductor industry S2-93A standards in mind.

For More Information Circle No. 753

Super-Bright Light Source

Gradient Lens, Rochester, NY, says that its new LUXXOR-24™ light source is bright enough for high-intensity applications such as video or still photography and illuminating large and dark cavities like turbine-engine combustion chambers. The device uses a 24-W metal halide arc lamp that generates little heat, making it possible to carry the housing in a pocket. Weighing about 2 lb. 1 oz., the light source is 1.6 times brighter than a typical 150-W tungsten halogen source weighing 6 to 9 lb. Expected lamp life is as much as 500 hours. Gradient Lens say the unit is compatible with most borescopes, including its own Hawkeye® line.

For More Information Circle No. 754

FTIR Spectroscopy Interferometer

The new interferometer from PLX Inc., Deer Park, NY, contains two mirrors and a beamsplitter fused with top and bottom glass plates of the same material. The company says this provides a monolithic structure of uniform coefficient of thermal expansion that allows greater stability under high-temperature and vibration conditions. The assembly's single PLX hollow retroreflector separates and recombines the beams for a double-pass configuration PLX says can accommodate any wavelength. The interferometer is available in quartz or BK7 for visible and near-IR applications, or with a KBr beamsplitter for the far-IR.

For More Information Circle No. 755

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2. Which of the following types of CAD software do you now use? (check one) ☐ 2D ☐ 3D ☐ Both

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TECH EAST '99

Highlights from the annual national technology transfer conference and exposition

Tech East '99 brought together three events — Technology 2009, the Engineering Innovation Show; Southeast Design & Manufacturing Expo; and the Small Business Tech Expo — at Miami's Fontainebleau Hilton in November. Sponsored by NASA, *NASA Tech Briefs*, the Federal Laboratory Consortium, and Hewlett-Packard, the shows drew design and manufacturing engineers and entrepreneurs looking for the latest technologies and products.

A featured event at Tech East was the first NASA Business Forum, which focused on emerging commercial opportunities in aerospace and aviation. Sessions covered how to do business with NASA, spaceports and spaceliners, medical benefits from the space program, and new initiatives in general aviation.

General Spence M. Armstrong, NASA Associate Administrator for Aero-Space Technology, opened the forum with "How to Do Business With NASA," an introduction to key NASA enterprises, including contacts, programs, and resources available to commercial industry. General Armstrong spoke about those partnership opportunities, and presented his views on the technology transfer process.

SBIR Technology of the Year Award nominee Genex Technologies displays their 3D imaging techniques to Tech East '99 attendees.

"The Aero-Space Technology Enterprise is unlike the other NASA enterprises. We're never finished. We're always looking for someone to finish the job. I sometimes say that our goals are like the tape at the end of a long relay race. It's not run against the competition, but against time. We never run the anchor leg. That's technology handoff. We want somebody who will take our technology and run with it, and cross the finish line," the General said.

General Armstrong explained that NASA has a mandate that "uses the taxpayers' money, so we should give them the maximum benefit for their money. We're not in the business to provide technology to the public. We're in the business to carry out our mandate of the Space Act — to make the technologies useful to the public," he said.

The session also included presentations from Dr. Robert Norwood, Director of Commercial Technology for NASA, who discussed the Commercial Technology Network. Vernotto McMillan, Deputy Director of the Technology Transfer Department at NASA's Marshall Space Flight Center explained the tech transfer process at his center. Finally, Lamont Hames, Small and Disadvantaged Business Specialist at NASA Headquarters, discussed opportunities for minority- and women-owned small businesses.

General Spence Armstrong (left) and Lamont Hames of NASA were panelists in a forum session for companies looking to do business with NASA.

Just What the Doctor Ordered

The potential of space technology to improve the quality of life on Earth is most dramatically demonstrated in the area of healthcare and innovative medical treatment. Helen Stinson, program manager of NASA Marshall's Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) program, was the moderator for a NASA Business Forum session devoted to medical advances. Topics included innovations in obstetrics, cancer surgery, and wound healing; a "bionic" eye; telemedicine in extreme environments; microgravity's impact on nutraceuticals; and biotechnology and drug discovery.

Daniel L. Wakefield, senior engineer at the Research Triangle Institute in North Carolina, led off with an overview of success stories and partnership opportunities in medical innovations. "The US commands a healthy market share in the medical device industry," he said. "But new products are critical to success. If we don't have new products coming out every year, we will start losing market share."

Wakefield cited several recent examples of NASA technologies that have been transferred to the medical device industry. These have led to the development of a non-invasive, intracranial pressure monitor for closed head injuries; vision-enhancement device; digital mammography; and an ultrasonic periodontal probe.

Obstetrical forceps are undergoing a 21st-century makeover, thanks to fiber-optic sensors developed for the X-33 reusable launch vehicle. "Since the 1930s, the forceps have not been innovated," according to Dr. Jason Collins of the Pregnancy Institute in New Orleans. "In terms of delivering babies, what we don't know is the force being used to deliver that baby — that's a critical issue."

Using conventional forceps during delivery increases the risk of brain damage and other serious injuries to the infant. Dr. Collins is participating in the development of "smart forceps" in which embedded fiber-optic sensors will enable the doctor to monitor the amount of force being applied throughout the delivery. Developing the new forceps involves finding a composite material equal in strength to steel, formulating an embeddable sensor, transforming force to a recordable pattern, accumulating case histories, and devising a 3D simulator/trainer.

Dr. Harry Whelan, a pediatric neurologist at the Medical College of Wisconsin, presented an LED probe that has been used in surgery to treat otherwise inoperable brain cancer. Quantum Devices originally developed the LED technology for plant-growth research on the Space Shuttle. The probe consists of 144 pinpoint LEDs that are used to activate a light-sensitive, tumor-destroying drug in a technique known as photodynamic therapy.

The potential exists to use photodynamic therapy to treat other forms of cancer, such as melanoma and other skin cancers. "Anywhere you can easily place the light probe is a possibility," said Dr. Whelan.

1999 SBIR Technology of the Year Award winners: (front row l-r) Kang Lee, Aspen Systems; Zafar Munshi, Lithium Power Technologies; Stephanie Vierkotter, Quantum Magnetics; Ian Ferguson, Emcore; and Dan Berger, Irvine Sensors. (Back row): Chief Editor Linda Bell and Publisher Joe Pramberger (far right) of *NASA Tech Briefs* with members of the Quantum Magnetics team.

Small Business Wins Big

Tech East '99 hosted the presentation of the annual SBIR Technology of the Year Awards, which recognize companies that have developed important new commercial products and services through the federal government's Small Business Innovation Research (SBIR) program. The program is the country's largest source of early-stage, high-risk technology financing, with some 5,000 grants totaling $1.2 billion awarded annually by ten federal agencies.

Winners were chosen in four categories, and a Grand Winner was selected as the best new technology. Emcore Corp. of Somerset, NJ, won the Computers and Electronics category with their indium-gallium-nitride-based material for bright, blue, light-emitting diodes (LEDs). The company received funding from the Ballistic Missile Defense Organization (BMDO) to commercialize the technology, which is in great demand for automobile tail lights and traffic lights.

The Manufacturing and Materials category winner was Aspen Systems of Marlborough, MA. The company developed an improved drying method for aerogels, the silica materials with densities as low as three times that of air. Widespread use of aerogel-based insulation would significantly reduce energy consumption and emissions.

The winner in the Sensors and Instrumentation category was Irvine Sensors of Costa Mesa, CA, for a 3D chip-stacking process in a neural network. The network emulates the human eye-brain interconnection, and has potential applications in medical diagnostics and security screening.

BMDO also funded the winner in the Health, Energy & Environment category. Lithium Power Technologies of Manvel, TX, created film hybrid dielectric capacitor materials based on polymer blends capable of high energy densities and able to be manufactured at a cost of about half that of existing film capacitors.

The Grand Winner was Quantum Magnetics of San Diego, CA, for their sensor that detects the explosive charge inside a buried land mine. The life-saving device employs quadrupole resonance (QR), a spectroscopic technique that involves illuminating a mine with radio frequency (RF) waves and measuring the RF response. The waves' frequency is chosen from a set of resonance frequencies unique to each explosive used in land mines.

New "Horizons"

A capacity audience attended "Tapping Into the Federal Laboratory Network to Improve Your Bottom Line," a session that featured information on partnership and commercialization opportunities with the Department of Defense and other major federal agencies. One of those agencies, the Air Force Research Laboratory (AFRL), announced during the session their partnership with ABPI, publisher of *NASA Tech Briefs*, to produce a new magazine for the US Air Force called *Air Force Technology Horizons*. The magazine, scheduled to debut in March, will report on new technologies available for commercialization from the AFRL. For more information on AFRL, visit the web site at www.afrl.af.mil; for more information on *Air Force Technology Horizons*, see next month's issue of *NASA Tech Briefs*.


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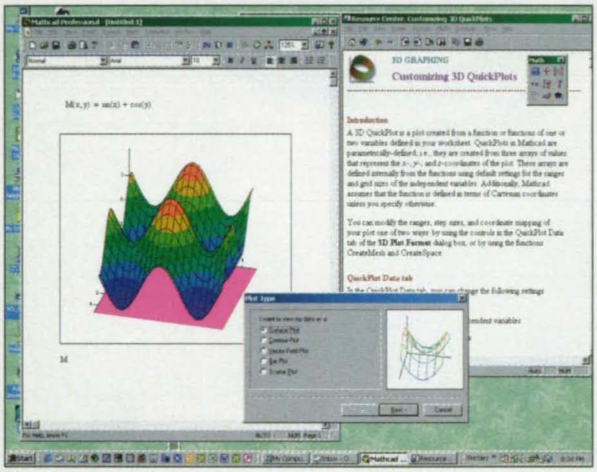
For More Information Circle No. 513

Beyond the Basics: Mathcad 2000

Steven S. Ross

The basics of Mathcad are fairly well known among techno-citizens: Copy an equation out of a textbook onto a Mathcad screen, and the math goes live. You can solve for any variable without bothering to transpose the equation. The unknown is on one side and all other variables and constants are on the other — the same as what you would do with a programming language such as C or BASIC. Mathcad can handle, among other things, basic linear equations with as many as 50 variables. This capability has been around since the early 1980s, when TKSolver was first developed.



Simple contour plot.

Mathcad (from MathSoft, Cambridge, MA; www.mathsoft.com) did TKSolver one better by adding a simple text processor, so you can handle engineering reports — words, equations, and graphs — with one package. Mathcad now also has automatic support for unit conversion. Combine calories and BTUs, and you get a combined answer that makes sense. I find this particularly magical because I wrote the original units-conversion add-on package for TKSolver back in 1983.

But Mathcad these days goes far beyond the basics. I had not looked at it in depth for about four years. I should have. And so should you.

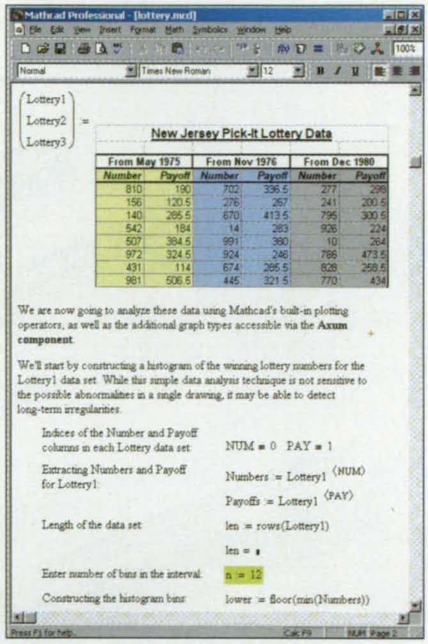
There's much more interactivity with other software. Mathcad 2000 is both an OLE2 (COM) server and client, so its functional equations can be plugged into a Word document, and data from another program can be plugged into Mathcad. The new version is particularly adept at exchanging data with MATLAB and with Excel (there's a special Excel plug-in that makes the two programs appear almost as one).

Mathcad 2000 comes in three versions: Premium ($999.95), Professional ($499.95), and the blowout-priced Standard ($99.95). The Standard version has everything that most people need at school or at home. Professional adds some advanced functions and a "lite" edition of Axum for graphs. Premium adds the full version of Axum, an "expert solver" (adapted from the solving and optimization add-on in Version 8) that allows mixed-integer programming, and the "treasury," a powerful reference tool.

All three versions include more statistical curve-fitting functions for exponentials, logs, power, periodical (mainly sinusoidal), and logistical data than in Version 8. While it is true that you could build these functions as you need them using Mathcad's own on-screen tools, having them built in allows faster execution and less chance for error.

More revolutionary is that all of the new versions now do equations with Boolean operations (AND, OR, NOT, XOR). The Professional and Premium versions include a new, powerful differential equation solver. The odesolve function is especially slick. It solves any single ordinary differential equation subject to either an initial value or boundary value. The equation must be linear in its highest-order derivative term. Also noteworthy in Version 2000 are great 3D graphics and (in Pro or Premium, with the Axum add-on) 2D plotting improvements. There's a link with SmartSketch (full version in Premium, LE in the other versions), the program from Intergraph that formerly was called Imagineer. It allows you to make computations based on values in your sketched drawings, and to import files from AutoCAD and other CAD packages so you can use the drawing dimensions as data. Finally, there is a new error-tracing tool and better equation and document formatting.

Using the basic functions of Mathcad does not require much orientation. You start on an almost blank screen and specify a region. As you start to type an equation, Mathcad always seems able to decide whether you are typing math or text. As you need special symbols and functions, you can pick them up from various toolbars scattered around the interface — one for calculus, one for matrices, one for standard math, one for Booleans, and so forth.



Start of a formatted analytical report. In this case, on the odds and payouts for the New Jersey Pick 6 Lottery.

If you do need help, you'll probably find it. The help system is quite good. It does require that you install Internet Explorer 4.0 or higher. Mathcad requires a Windows 95/98/NT Pentium computer with 32 to 64 MB of RAM. Complete installation of the Professional version takes about 130 MB of disk space.

Steven S. Ross is an associate professor at Columbia University in New York City. He has authored three commercial software packages, including a units conversion program and an engineering calculations program.

Commercialization Opportunities

Composite-Material Heat Sink for Printed-Circuit Boards

A lightweight heat sink and mechanical support has been developed for printed-circuit boards. The heat sink weighs 43 percent less than an aluminum heat sink does.
(See page 40.)

Reducing Methanol Crossover in CH_3OH-Fuel-Cell Membranes

Improved membranes can be made by impregnating the baseline membrane material with cross-linked polystyrene. The principal benefit is a reduction in permeability by methanol, which otherwise wastes fuel and degrades fuel-cell performance.
(See page 41.)

Inflatable Wing Leading Edges for High Lift and Deicing

Preliminary results demonstrate the feasibility of using inflatable boots on the leading edges of airplane wings to increase lift and to act as deicing actuators.
(See page 42.)

Improved Urine Preservative

A new solution eliminates the need to refrigerate urine samples and does not alter the pH values of the samples.
(See page 46.)

Noninvasive Determination of Pressure in Cerebrospinal Fluid

The proposed technique could make it unnecessary to perform spinal taps. This noninvasive technique involves tomographic scanning and digital processing of the image of the inside of the eye to determine the cerebrospinal fluid pressure.
(See page 47.)

Primers for Amplifying CMV DNA in Body Fluids and Tissue

A set of primers has been developed for faster, more sensitive detection of cytomegalovirus (CMV). CMV annually infects about 40,000 infants in the U.S. alone and is the leading infectious cause of mental retardation and nonhereditary sensoneureal deafness.
(See page 48.)

High-Temperature Pressure Sensors Made From Silicon Carbide

These are prototype sensors for use at high temperatures in engines, power plants, material-processing systems, and numerous other applications. Their working temperatures range up to 500 °C.
(See page 57.)

Nonintrusive Flow-Measurement System

Flow is measured ultrasonically from outside the pipe. This design eliminates a number of potential mechanical failures that can happen in conventional flowmeters and eliminates the risks of leakage, clogging, and corrosion.
(See page 57.)

Piezoelectric Igniter/Pressure-Sensor Devices

These devices would supplant conventional spark plugs in internal-combustion engines. Unlike conventional spark plugs, these devices would work without need for wire connections to high-voltage sources and without external timing circuitry.
(See page 58.)

NASA Uses Radiance Infrared Camera for Component Evaluation

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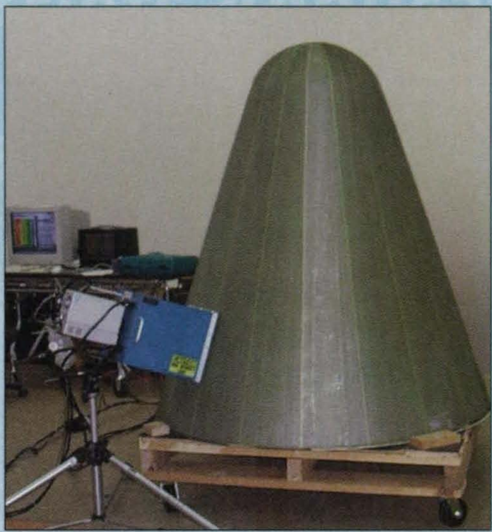
NASA's Marshall Space Flight Center (MSFC), Huntsville, AL, is testing Raytheon's Radiance infrared camera to devise nondestructive evaluation (NDE) methods for assessing Space Shuttle and other aerospace components. MSFC researchers are combining thermography, ultrasound, and radiography technologies in various ways to develop these NDE techniques, which will be used to identify structural anomalies in components. Researchers are using the Radiance for the thermography component because the camera's 256-x-256-pixel InSb staring focal-plane array generates high-resolution images and is highly sensitive to slight temperature changes.



The infrared camera is used to image the Space Shuttle nose cap.

With the Radiance, MSFC has conducted nondestructive evaluations of various Space Shuttle components, including a prototype nose cap for the shuttle's Reusable Solid Rocket Boosters. Six feet high and four feet wide at its base, the nose cap consists of a foam core sandwiched by inner and outer graphite-epoxy skins.

Sam Russell, Ph.D., an NDE specialist at NASA Marshall, said thermography is useful for identifying anomalies, such as delaminations, in composite material. Proper functioning of the nose cap requires that the core and inner and outer skins be perfectly bonded throughout the cap structure. Delaminations and other anomalies can occur during composite manufacturing or be caused by something such as an object striking the outer skin.

According to Russell, the Radiance camera's 0.025C° sensitivity enables the camera to detect slight subsurface anomalies. "This high sensitivity is critical to us. Even the most subtle anomalies, such as minute delaminations, can cause problems, and we must be able to detect them," Russell said. He emphasized that MSFC's testing of various NDE methods is ongoing. Most likely, any final NDE procedures will combine, in some manner, thermography, ultrasound, and radiography.

For More Information Circle No. 742

Anchor Pins Selected for Space Station Crew Return Vehicle Testing

Force test hardware
Strainsert
West Conshohocken, PA
610-825-3310
www.strainsert.com

NASA's X-38 technology demonstrator is an emergency Crew Return Vehicle (CRV), or lifeboat, for the International Space Station. The design uses a lifting body concept, that upon jettison of a de-orbit engine module, the X-38 will glide from orbit, unpowered, like the Space Shuttle. It will use a steerable, parafoil parachute, and will touch down on landing gear consisting of three skids, rather than wheels.

Strainsert designed and developed three instrumented clevis pins to measure the unknown forces exerted on the vehicle's landing skid joints. The force data will be used to evaluate and verify the skid design loads and distribution. The pins were custom-designed for integration into the port, starboard, and forward pin joints of the landing skids. Requirements for each pin included a high measurement load combined with impact loading, a wide temperature range over which data must be acquired, and little or no modification to existing hardware.

To meet the requirements, the pins consist of cylindrical pins, instrumented with strain gages to sense shear strain in direct response to the applied load. The strain gages were internally installed and bonded in small holes along the neutral axis at the sensing sections of the pin, with the orientation aligned in accordance with the direction of the applied load to be measured. The pins are made of steel alloy with nickel plating, and are capable of withstanding over 40,000 pounds of applied double shear load for a 1" pin diameter.

The X-38 shown during a test landing at NASA's Dryden Flight Research Center. (Photo by Bill Isbell)

The pins were used successfully during landing tests. Future tests using the pins are scheduled for this spring. Later this year, the unpiloted test vehicle is planned to be deployed from a Space Shuttle and descended to a landing.

For More Information Circle No. 743

We Did It!

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For More Information Circle No. 533

Technology Forecast

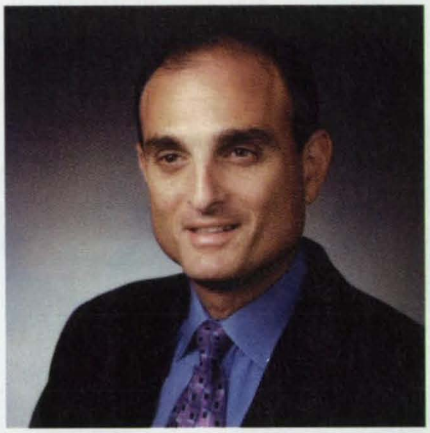
This month's technology forecast for the data acquisition industry is contributed by Tom DeSantis, President of IOtech, Cleveland, OH. Tom discusses why the time is right for synchronous measurement on low-cost PC plug-in boards.

Advancements in personal computer technology continue to push the world of data acquisition to new capabilities. Many of the analog measurements that were once made with digital multimeters, dataloggers, and chart recorders are now made with PC plug-in data acquisition boards. In addition to measuring analog signals, these boards also have the ability to acquire digital, counter, and frequency input signals, and to output analog and digital signals.

Historically, plug-in boards have done an excellent job of providing time-synchronized analog measurements, where the time relationship between each measurement — even on multiple channels — was precise and predictable. This is particularly important when waveform measurements are made, since the time relationship between multiple channels is almost always necessary to accurately correlate the acquired data.

Take an example where an analog-to-digital (A/D) board uses a 100K-kHz A/D converter, and two channels are to be measured at exactly 10 kHz per channel. Nearly all of today's boards are capable of measuring first one and then the other of the two channels at precisely 50 kHz per channel, with a mere 10-sec (1/100-kHz) time skew between them. Since the time relationship between the sampling of each channel is precise and deterministic, the acquired waveforms can be analyzed relative to one another with precision.

The problem with most of today's A/D boards is that most or all of their other I/O capabilities cannot be time-correlated to the analog measurements, or to each other, making it nearly impossible to correlate analog measurements to digital, counter, or frequency measurements. Consider a test example in which a board would be used to test a rotating motor in a piece of machinery. It may be desirable to measure various supply voltages and currents to the motor, the motor's RPM, the status of control switches, temperature, and perhaps other parameters. Thus, not only is it necessary to acquire analog data, but digital input data and counter/frequency data as well. In addition, it may be desirable to output an analog waveform from the board's D/A converters to create a dynamic load to the motor, or to output a control signal from the board to apply an impulse load to the motor.



Tom DeSantis, President, IOtech

Nearly every A/D board available today would have difficulty performing this test, because the analog output, digital I/O, and counter/frequency input are updated or measured asynchronously to the analog input scanning, making it nearly impossible to time-correlate the various I/O functions. The reason is that, while most boards operate their A/D converters and multiplexers from precise, clock-driven electronics, the other I/O usually is controlled via software in the PC. In addition, since all PCs operate at different speeds, the rate at which they can access the hardware is highly dependent on what other tasks are being performed at the time. The timing of the other I/O is almost entirely non-deterministic.

Notable exceptions are some higher-end boards with on-board intelligence, which have their own processors that are dedicated exclusively to managing the I/O functions. These boards typically are two to ten times more expensive than the typical multifunction A/D boards, and often require the use of a unique programming environment in order to accomplish the time-correlated multifunction I/O.

New Technologies Drive the Future

Now that PCs are faster than ever before, and with the advent of the PCI bus as the backbone for all new PCs, the future is bright for using low-cost plug-in boards to accomplish time-critical, multifunction I/O. Besides the cost advantage over processor-based plug-in boards, using low-cost, non-processor boards for multifunction I/O means that they can be programmed with popular and low-cost standard languages such as C++ and Visual Basic.

Two technology advancements are making the use of low-cost plug-in boards for time-critical multifunction I/O possible. First, the PCI bus, now ubiquitous on today's PCs, has the bandwidth necessary to acquire data from multiple sources on a single, low-cost plug-in board, as well as to generate multiple channels of output to the same plug-in board. The 15-year-old ISA bus, which has only recently been replaced by PCI, simply couldn't deliver this bandwidth.

The second advancement is the way in which multifunction A/D boards are designed. In the past, standard digital I/O devices, such as the 8255 chip, were used for digital I/O on nearly all boards. And the 9513 device was used to provide the counter/timer capability on most boards.

For less than $500, these new boards are capable of synchronously measuring analog inputs, generating analog outputs, acquiring digital inputs, controlling digital outputs, measuring counter inputs, and generating digital patterns — all in synchronicity with one another. Although most multifunction boards have yet to offer this capability, it's only a matter of time before these capabilities are considered standard features for low-cost plug-in boards.

For more information, contact IOtech at 25971 Cannon Rd., Cleveland, OH 44146; Tel: 888-805-3020; Fax: 440-439-4093; www.iotech.com.

Post-Processing Satellite Image Data in Secondary Schools

Direct experience helps prepare children for participation in an increasingly technological world.

Goddard Space Flight Center, Greenbelt, Maryland

Never before have secondary schools been able to post-process raw satellite data, and now they can do it in real time. This is credited to advances in technology that have recently made the necessary equipment simple, inexpensive, powerful, and available enough for any school to fit into their technology-education curricula. This equipment couples ideally with the emerging utilization of the Internet in secondary schools.

Such precursors to the Internet as the direct satellite broadcasts called Advanced Picture Transmissions (APT) and Weather Facsimile (WeFax), were placed in schools over the past 15 years but never integrated into the curriculum. They provided Graphic Image Files (GIFs), i.e., snapshots of scenes taken by satellites of the Earth below, by polar orbiting (NOAA) and geosynchronous (GOES) satellites, respectively. The operators of the satellites would produce these products on the ground and then uplink them to the same satellites for rebroadcast to the public. Users had no control over what images would be received nor could they enhance them to any notable extent. Recently, the Internet has supplanted this pathfinding service, by enabling the user to request such "canned" images on demand. Yet, due to the enormous amount of data in a single raw image (up to 385 MB), any attempt to access the raw data over the Internet must be severely constrained. Even high-speed connectivity is bogged down by the number of users all too quickly to use the Internet, for accessing anything larger than snapshots. This inherently limits the utility of the Internet services alone.

Now, innovations sponsored by GSFC have enabled us to bring raw, highest resolution, real-time data from the NOAA and GOES satellites to the secondary schools nationwide without compromise, at a price and complexity that they all can afford. This has required advancements in antenna design, a PC-based ingest and image processing system, and a curriculum that meets core learning goals and will be used by the teachers.

Standing Acoustical Wave (SAW) technology was applied to the low noise amplifier inside the antenna feed to better isolate the satellite downlink frequency and remove more of the background noise. This signal is then down-converted inside that feed to a lower frequency, before more noise can be picked up. The lower frequency preserves the signal-to-noise ratio along 300-ft (91-m) of inexpensive coaxial cable. A standard 10-ft (3-m) antenna, used by homeowners for satellite TV, was adapted with this new feed, keeping the antenna costs to a minimum. Next, the expensive ($30k) radio receiver normally employed for access to multiple satellites was replaced by a tailored version on a PC board that can sell for under one thousand dollars. Likewise, the related external components were all designed onto PC boards, so that now the antenna feed plugs right into your PC, with no external components.

The software was rewritten to work on personal computers, which guarantees that the system will get faster, better, and cheaper every few months. At this writing, the entire system costs between $5.5k and $8.5k depending on the sophistication of the server computer and economy of scale for software licensing. Compare this to almost $200k for the first systems that NASA used to handle these functions.

The use of these new tools in secondary schools was introduced in 1996 when they still cost $25k. At that time, GSFC augmented the costs for two schools in Maryland and Pennsylvania, and they agreed to use the systems in technology-education programs.

Curricula were developed jointly over the next two years as the technologies and the application software improved and the price came down. Currently, schools in six states, including the Pine Ridge Indian Reservation in South Dakota, are using these systems for academic credit. Students can use their Internet service to get ground truth images of wildfires, ocean currents, rain, snowfall, and the like. They can then locate the same time and place in their large data base of the raw satellite data, and custom enhance their images to match the ground truth. Having developed a suitable algorithm for rainfall where there is Doppler data and bucket measurements, they can now apply that algorithm to anywhere in the Western Hemisphere. Furthermore, using the continuous data from the geostationary satellites (GOES) they can apply their algorithms to the same scene every half hour or so and put it in motion. Now they can watch the rain/snow in motion or the wildfires move as they burn. Using emerging information technologies, they can e-mail their customized film loops to other schools nationwide or beyond. The learning potential is enormous. They learn marketable technology skills in the areas of electronic access of information, post-processing of raw satellite image data, multimedia production, and both electronic and verbal communication skills, while doing really cool science projects. This critical part of the overall program has been a product of cooperation between the educators and NASA, as is essential if it is to be used for academic credits on a nationwide scale.

This work was done by Michael Comberiate of **Goddard Space Flight Center**, *George Isleib of GTI Electronics, and Shawn Terry of Aquila Systems. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category, or access the website: http://coolspace. gsfc.nasa.gov/*
GSC-14038

Using Narrow-Band Data Links in Locating Lightning Strikes

Electric-field waveforms are preprocessed to extract selected characteristics.

John F. Kennedy Space Center, Florida

A method of preprocessing lightning-measurement waveforms has been devised to reduce the bandwidth needed to transmit data for computing the locations of lightning strikes. The method is used in a system in which electric fields and electric-field derivatives induced by lightning are measured at remote stations and the measurement data are transmitted to a central station. At the central station, the location of each lightning strike is computed from the known positions of the stations, the speed of light, and the differences among times of arrival of common waveform features at the remote stations. Prior to the development of the present method, in order to achieve a required spatial resolution of tens of meters, it was necessary to transmit full measurement data from each remote station to the central station in real time at a bandwidth of 10 MHz.

The preprocessing method exploits the following two concepts:

- A lightning strike typically comprises multiple strokes 20 to 50 ms apart, each stroke lasting of the order of 0.1 ms. Even during an intense thunderstorm, lightning strikes usually occur no more frequently than once every few seconds. Given this essential intermittency, the data-transmission bandwidth necessary to accommodate the time-averaged data rate is much less than the real-time, full-resolution bandwidth of 10 MHz. Thus, by abandoning real-time transmission, one can make possible a reduction in the data-transmission rate.
- If one extracts data on waveform characteristics that can be used to establish times of arrival, then the remaining waveform data can be discarded to effect a further reduction in bandwidth.

In this method, each remote station is equipped with a digitizer and an embedded controller. When a signal exceeds a predefined threshold, digital samples of the signal are taken at a rate of 20 megasamples per second for an observation interval of 100 μs. The record of samples is time-stamped with the starting time of the observation interval as determined by a differential Global Positioning System (GPS) receiver.

Still at each remote station, waveforms are characterized in terms of time elapsed between largest peaks (both positive and negative), rise times, durations at half maximum amplitudes, and other parameters. Each such characteristic is encoded in two bytes: one that identifies the characteristic and one that gives its value. The resulting code data and the time stamp are then transmitted to the central station for processing.

In the central station, the data from the remote stations are lined up in a search for matches among the characteristics. Differences among times of arrival are then determined on the basis of the best match.

The accuracy of the estimated differences among times of arrival increases with the number of characteristics. About 10 unique characteristics are enough to obtain good alignment. The bandwidth needed to transmit 10 coded characteristics and the accompanying timing data is 5 kHz — only 1/2,000th of the bandwidth needed for real-time transmission of full waveform data.

This work was done by Jose M. Perotti of **Kennedy Space Center** *and Pedro J. Medelius, formerly of I-NET, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11955.

Centralized Electronic Reporting of Material-Science Tasks

Expensive and time-consuming distribution of, and searches among, paper documents are no longer necessary.

John F. Kennedy Space Center, Florida

The Materials Science Division (MSD) at Kennedy Space Center is developing a computer system to maintain a material-science data base coupled with a user-friendly interface on the World Wide Web. The system is designed to eliminate the need for time-

consuming and expensive distribution of, and searches among, paper documents.

The system comprises two main parts: the MS Report Log and the MSD Report Server. The MS Report Log facilitates tracking the statuses of tasks and maintaining documentation pertinent to those tasks in various subdivisions of material science, including failure analysis, chemical analysis, metallurgical evaluation, and physical testing. The MS Report Log serves as a unified medium for reporting, replacing a disjointed combination of paper and computer logging and reporting by mail and telephone. The MS Report Log is accessible via any computer workstation running commercially available web-browser software.

The MS Report Log automatically sends, by electronic mail, notices of changes in a task to all investigators, their supervisors, and others who are involved in or have expressed interest in the task. A person using the MS Report Log can view all data related to a task, can (if authorized) request a new task, and can download reports of tasks electronically. Investigators and their supervisors can update selected task fields in the data base, generate reports, and add related documents.

The MSD Report Server, still undergoing development, is intended to serve as an electronic archive of all MSD reports, which have been accumulating since the early 1960's. The MSD Report Server would provide quick and easy access to documents, many of which are, variously, inaccessible or accessible only through consultation with experts: These documents — about 45,000 in all — are in paper form, stored in boxes and filing cabinets in various laboratories, each of which uses its own report-numbering system. In addition, laboratories have been divided, merged, and renamed over the years, and experts who retain the institutional memory of the report files have retired, so that it is becoming increasingly difficult to locate old reports on specific parts or materials that could be relevant to current investigations.

The paper documents would be scanned and digitized to generate the data for the MSD Report Server. Reports would be indexed and would be accessible via keyword searches entered via the MSD Report Search web page. Each report would be made available electronically, in both full text and portable document format (PDF). The PDF versions of reports would include images. PDF-viewer software can be downloaded via the MSD Report Search web page. Optionally, each report could be reprinted in its original format. At present, only Kennedy Space Center personnel have access to the MSD Report Server; eventually, wider access will be allowed.

This work was done by Scott Murray, Tim Bolo, Debra Folmar, Bill Dearing, and Angela Balles of **Kennedy Space Center** *and William I. Spiker II and Nancy Tuttle, formerly of I-NET, Inc.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11948/60.

Algorithm for Rapid Acquisition of a PPM Optical Signal

Data frames can be synchronized with part of the synchronization sequence.

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm for rapid acquisition of a pulse-position-modulation (PPM) optical data signal implements a pattern-matching technique for synchronization of receiver timing with the temporal boundaries of data frames. Synchronization is necessary because in PPM, information is conveyed by the time slot during which a pulse is detected. Fast acquisition of a signal depends on detection of pulses in noise, and on correct estimation of the times of detected pulses. To facilitate synchronization at the receiver, a transmitter periodically inserts a prescribed sequence of pulses — the synchronization sequence or word — into the transmitted data stream. Older PPM-signal-acquisition algorithms are based on correlations and depend on reception of the full synchronization word (128 bytes long in some applications). The present algorithm is more computationally effi-

Received Pattern: 1 0 1 (Two Bytes Received)
WS: 1 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 1 1 1 0 1 1 1 1 1 0 0 1 0 0 1 1 ← Synchronization Word
PPL: 0 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 ← Four Possible Locations of Received Pattern

Received Pattern: 1 0 1 1 (Three Bytes Received)
WS: 1 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 1 1 1 0 1 1 1 1 1 0 0 1 0 0 1 1 ← Synchronization Word
PPL: 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 ← Two Possible Locations of Received Pattern

Received Pattern: 1 0 1 1 0 1 (Four Bytes Received)
WS: 1 0 0 0 0 1 0 1 1 0 1 0 1 0 0 0 1 1 1 0 1 1 1 1 1 0 0 1 0 0 1 1 ← Synchronization Word
PPL: 0 0 0 0 0 1 0 1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 ← One Possible Location of Received Pattern: Synchronization Complete

Received Byte Patterns are compared with sub-sequences of a 32-bit synchronization sequence. Matches with sub-sequences of increasing length are sought until the received pattern matches a unique sub-sequence.

cient and is capable of achieving synchronization with part of the synchronization word — typically with as few as 2 to 6 bytes.

The algorithm involves, among other things, selective elimination of unlikely starting points for a sequence of received pulses detected in the presence of noise. It is assumed that the pulse-detection threshold of the receiver is set at a level that corresponds to a specified bit-error probability. The receiver is switched on at a random time, and a search for the synchronization sequence is started. The objective of the algorithm is to uniquely identify the temporal location of a received sub-sequence of the synchronization sequence.

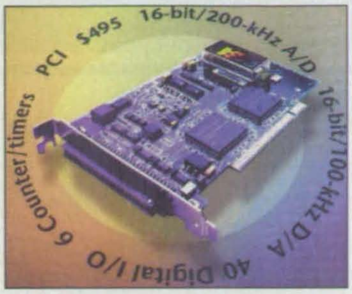
Initially, the algorithm seeks all possible candidate sub-sequences that match a received 2-byte sequence. The process continues with the reception of additional bytes; the algorithm seeks matches with 3-byte sub-sequences, 4-byte sub-sequences, and so forth, until it eliminates all candidate sub-sequences that do not match and arrives at a single unique sub-sequence and thereby establishes the receiver timing relative to the entire synchronization sequence. The figure presents an example of this process in the case of a 32-byte synchronization sequence.

When real data are interleaved between periodic transmissions of the synchronization sequence, data-bit patterns can sometimes be identical to sub-sequences of the synchronization sequence. Random bit flips caused by noise can also cause bit patterns other than the desired ones to alias as synchronization sub-sequences. To reduce the incidence of such errors, one can require confirmation in the form of additional received bytes beyond those needed to establish a unique synchronization sub-sequence; the additional bytes are said to constitute a confirmation sequence. The probability of false synchronization is inversely proportional to the length of the confirmation sequence.

The procedure for confirmation immediately follows the identification of a unique sub-sequence and determination of its starting time. The unique sub-sequence enables the algorithm to predict the arrival of the next pulse in the known synchronization sequence. If the next detected pulse arrives at the expected time, confirmation continues with the next pulse, and so on, for as many pulses as required for the confirmation sequence. If all predictions and observations have been found to match when the confirmation procedure has been completed, then synchronization is deemed to have been achieved and the temporal boundaries of data frames are calculated. If a mismatched pulse is detected during the confirmation procedure, then the algorithm resets.

This work was done by Payman Arabshahi, Tsun-Yee Yan, and Kourosh Rahnamai of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*
NPO-20528

Special Coverage: Data Acquisition



IOtech, Cleveland, OH, offers the DaqBoard/2000™ **PCI data acquisition board**, which is designed for high-speed, plug-and-play PC-based acquisition. The board includes 16-bit, 200-kHz A/D; bus mastering; dual 16-bit, 100-kHz D/As; 40 digital I/O lines; four counters; and two timers. Also offered are signal conditioning and expansion options for thermocouples, RTDs, accelerometers, isolation, high-voltage, strain gauges, and current.

Up to four boards can be installed into one PC. One 100-pin connector provides access to all input and output signals. Users can expand the board up to 256 analog inputs. An on-board scan sequencer allows selection of any combination of up to 512 channel/range combinations. Software support includes drivers for programming tools such as Windows® 95/98/2000/NT, Visual Basic®, C++, and LabVIEW®.

For More Information Circle No. 733

The DEWE-3010 **data acquisition system** from Dewetron, Wakefield, RI, combines a portable industrial computer with slots for 8 modules that adapt the system to virtually any sensor. The CPU is a 400-MHz AMD K6®II, with a 100-MHz bus, and features 128 MB RAM and a 4 or 9 GB hard disk drive. It also features a USB interface, built-in CD-ROM drive, 12.1" display, and internal UPS. The system can expand to 2,048 channels.

The connectable modules power virtually any sensor, provide up to 1500 Vrms of isolation, and include anti-aliasing filters. They provide up to 8 input channels each, and 8 modules can be plugged into the system. DEWEScope+ software provides set-up for the system. The modules are software controllable; the software is included. Any Windows application can be run on the system.

For More Information Circle No. 731

Keithley Instruments, Cleveland, OH, has introduced the Integra Series Model 2700 **multimeter/data acquisition system** that combines a high-channel-count datalogger with a 22-bit DMM. The half-rack-size system can perform up to 80 channels of measurement and control. The system can function as an integrated, PC-based, mini-ATE system. Built-in mainframe signal conditioning can handle inputs up to 1000V.

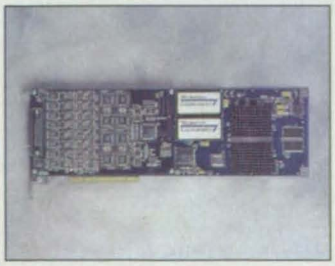
Two card slots accept a variety of input modules, with the ability to vary channel count from 20 to 80, apply a stimulus to DUTs, route signals, control system components, and make measurements with 13 different test functions. D-Sub or oversize screw terminal connectors are available. With DMM-like pushbutton controls and front/rear inputs, users easily can collect data and/or perform troubleshooting. Communication with a PC is via a GPIB or RS-232 interface.

For More Information Circle No. 730

Vision is a **portable data acquisition system** from Nicolet Technologies, Madison, WI, that combines elements of DAT recorders, oscillographs, and oscilloscopes. It provides real-time scrolling, triggered, or XY displays, and has removable storage. The system's universal amplifiers provide 500V isolation, with 16-bit digitizers on each channel. Eight channels at 100 kS/s each can be recorded in 80 minutes; 16 channels at 1 kS/s can be recorded over three days.

Other features include 20 kHz analog bandwidth, universal isolated signal conditioning, a lightweight enclosure, continuous recording at full acquisition speed to an 8-GB hard disk or 2-GB Jaz drive, and 100 base-T Ethernet and IrDA connection to external devices. A sound channel records user comments, and 8 digital inputs record status bits, frequency, or RPM.

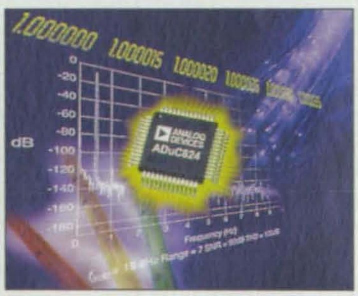
For More Information Circle No. 728



Microstar Laboratories, Bellevue, WA, offers the iDSC 1816 **data acquisition board**, an eight-channel, 16-bit resolution board for the PCI bus. The board, designed for those PC-based systems requiring anti-aliasing filters, has onboard filters that combine analog and digital algorithms. The board acquires data at up to 153.6 Ksamples per second per channel, and filters signals for all types of spectral analysis.

The user can control the board from any Windows system that contains the board, or remotely from any other Windows system on the same network. The board also features 8 differential inputs with simultaneous sampling and independent filters, and expansion to 112 simultaneous channels in one PC. Software included with the board configures it for data acquisition, and also acquires, graphs, and logs data. The software includes drivers for HP VEE, LabVIEW, DASYLab, and DIAdem.

For More Information Circle No. 729



The ADuC824 MicroConverter™ **data acquisition system on a chip** from Analog Devices, Norwood, MA, is a data conversion, program and data flash memory, and 8-bit microcontroller. It provides a programmable sigma delta converter, and incorporates a mixed-signal integrated circuit architecture. It is suited for calibrating and conditioning analog and digital sensor signals in portable applications, medical instrumentation, or sensor interfacing.

The chip's mixed-signal integration incorporates two high-resolution analog-to-digital converters, temperature sensor, programmable-gain amplifier, 12-bit digital-to-analog converter, 8-bit microcontroller unit, flash memory, random-access memory, and serial ports. It operates from a 32-kHz crystal with an on-board phase-lock loop, from a single 3V or 5V power supply.

For More Information Circle No. 732

Electronic Components and Systems

Tunable HTS/Ferroelectric Microstrip Band-Pass Filters

These filters are designed for operation at temperatures less than about 77 K.

John H. Glenn Research Center, Cleveland, Ohio

Electrically tunable microstrip two-pole band-bass filters for a center frequency near 19 GHz and a 4-percent bandwidth have been designed, fabricated, and demonstrated to be functional. These filters are suitable for use in the front ends of K-band communication receivers that operate at low temperatures.

Figure 1 depicts the multilayer configuration and microstrip layout of one of these filters. The top layer is a thin film of the high-temperature superconductor (HTS) $YBa_2Cu_3O_{7-\delta}$ patterned into microstrip lines. The top layer rests on a layer of the ferroelectric material $SrTiO_3$, which rests on a dielectric layer of $LaAlO_3$. The bottom of the $LaAlO_3$ is coated with a thin film of a normal conductor (Au), which serves as a ground plane.

Tunability is achieved through the nonlinearity (specifically, the variation of permittivity with electric field) of the $SrTiO_3$ layer. Using a commercial electromagnetic-analysis computer-aided-engineering software package, the design of the filter was optimized so that normal operation at the center frequency would occur when the relative permittivity ε_r of the $SrTiO_3$ was 1,650. This resulted in a requirement to maintain a suitable bias in order to maintain ε_r at 1,650.

Prototypes of these filters were packaged for swept-frequency measurements of their scattering parameters (S_{ij}) in a helium-gas closed-cycle cryogenic system. In experiments on tunability, a dual-polarity biasing technique was used: Referring again to Figure 1, nodes A and C were biased with a positive voltage, while nodes B and D were biased with a negative voltage of equal magnitude. The dc bias connections at A and D were made via input and output bias tees; the bias connections at B and C were achieved via gold-wire bonds on radial biasing stubs. The dc bias was increased from 0 to ±500 V in steps of ±50 V.

Figure 2 depicts results of some of the measurements; namely, the frequency and voltage dependence of S_{11} and S_{12} of one of the filters at a temperature of 77 K and an input power of 10 dBm. With increasing bias voltage, the center frequency of the filter shifted from 17.4 GHz at no bias to 19.1 GHz at a bias of 500 V, giving a tunability factor of 9 percent. The lowest measured pass-band insertion loss

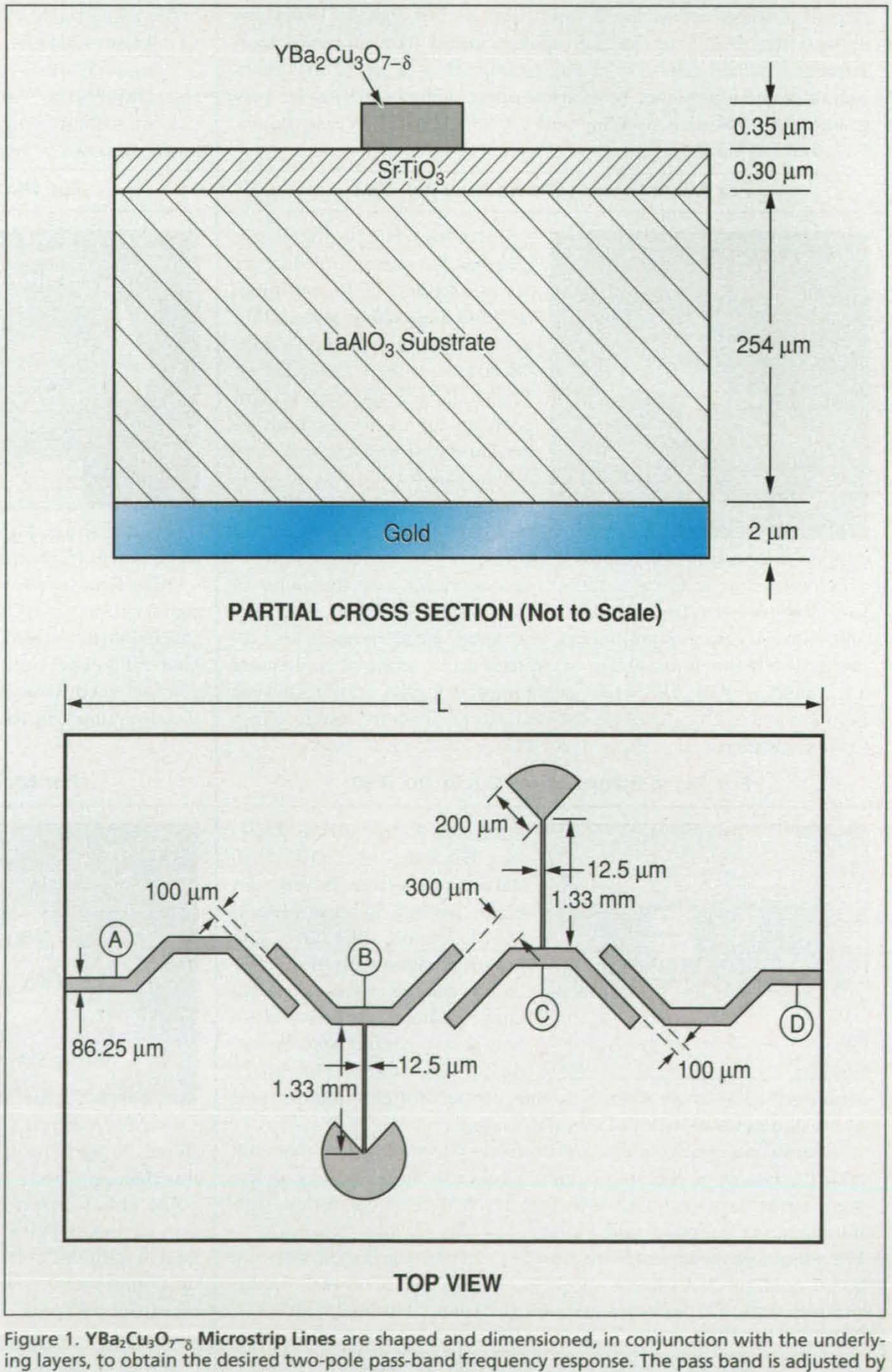


Figure 1. **$YBa_2Cu_3O_{7-\delta}$ Microstrip Lines** are shaped and dimensioned, in conjunction with the underlying layers, to obtain the desired two-pole pass-band frequency response. The pass band is adjusted by varying the dc bias and thus the electric field in the $SrTiO_3$ layer.

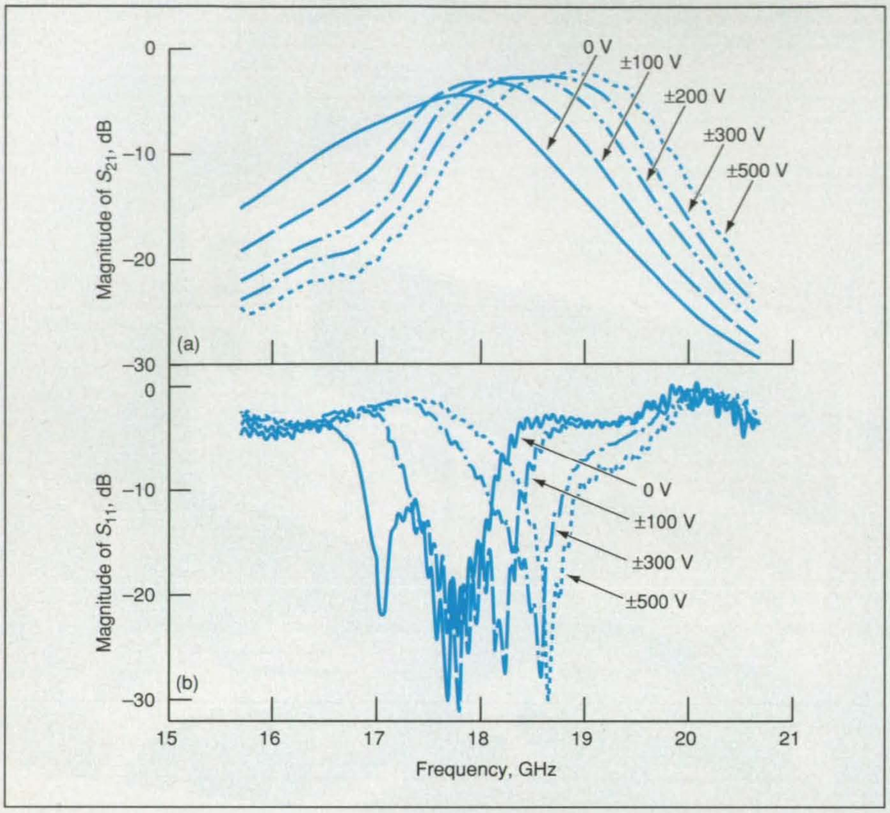


Figure 2. **S_{11} and S_{12} of a Filter** were measured at 77 K. These plots show the desired voltage dependence of the pass band, plus a desirable increase in S_{12} and a desirable decrease in S_{11} with bias voltage.

of this filter was 1.5 dB at 24 K. Another filter exhibited a tunability factor of 12 percent at a temperature of 30 K. In general, the return losses S_{11} and S_{22} of the filters were near or greater than 10 dB in the pass band. The resonance quality factor (Q) of the filters in the absence of loading was estimated to be ≈ 200. Efforts to optimize the HTS and ferroelectric films to obtain lower insertion losses and better tunability near 77 K and at lower bias voltages were underway at the time of reporting the information for this article.

This work was done by F. A. Miranda of **Glenn Research Center**, *F. Van Keuls of the National Research Council and G. Subramanyam of the University of Northern Iowa. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16751.

Return-Link Processor PCI Card

Relative to prior return-link circuitry, this card is smaller, less power-hungry, higher performance, more versatile, and much cheaper.

Goddard Space Flight Center, Greenbelt, Maryland

The return-link processor card (RLP) performs all of the fundamental data-processing functions involved in the return of satellite telemetry, in real time at rates up to 400 Mb/s, using industry-standard interface circuitry and connectors with standard sizes and shapes. Previously, four cards, each containing a central processing unit (CPU), were needed to do what the RLP now does. CPU-based cards are complex; are expensive to build, operate, and maintain; are susceptible to malfunction; and require a great deal of power and cooling.

Functions of the RLP include frame synchronization, cyclic-redundancy-code and bit-transition-density decoding, detection and correction of errors by use of Reed-Solomon codes, processing according to the Consultative Committee for Space Data Systems (CCSDS) standard for Advanced Orbiting Systems (AOS) service, and CCSDS conventional processing of packets and frames of telemetric data. The RLP can also synchronize frames of data in a weather-satellite-data format and in other formats. Data received via the Internet and other low-rate sources accessible by a computer can be injected directly by the host computer in which the RLP is installed.

The RLP is a single industry-standard peripheral component interface (PCI) expansion card. In addition to the industry-standard PCI connector, it contains industry-standard subminiature B connectors for emitter-coupled-logic (ECL) input, an industry-standard DB-9 connector for RS-422 input, connectors for programming nonvolatile logic devices and a connector for an optional sorting module (OSM — a mezzanine board on which additional buffering, processing, and output functions can be implemented.)

The RLP contains the following circuits:

- An ECL input interface circuit,
- An RS-422 input interface circuit,
- A special-purpose parallel intgrated frame-synchronizing application-specific integrated circuit (ASIC),
- A special-purpose Reed-Solomon error-detecting-and-correcting ASIC,
- A custom ASIC for CCSDS AOS Service and conventional CCSDS processing of packets and frames,
- A PCI-bus-interface ASIC,
- A custom direct-memory-access interface reprogrammable, nonvolatile logic circuit,
- A custom reprogrammable nonvolatile logic circuit for monitoring and controlling the other circuits,
- A custom reprogrammable nonvolatile logic circuit that serves to collect status from the other circuits and supply it as a telemetry data stream, and
- Miscellaneous active and passive devices.

During typical operation, a standard serial data stream enters via either the ECL or the RS-422 input path, is processed in data-flow fashion through the ASICs, and is deposited in a number of first-in/first-out (FIFO) memory buffers onboard the RLP. Setup, control, retrieval of data, and monitoring are performed through an entirely memory-mapped PCI interface by software running on the host computer. The presence of data can be detected either by use of interrupts or by polling. Monitoring information is semiautomatically collected into easy-to-retrieve data blocks.

In comparison with the previous assembly of four cards, the RLP is smaller, less expensive, faster, and more energy-efficient. The CPU-less, memory-mapped mode of operation of the RLP is simpler and more robust than was the CPU-based operation of the previous assembly. The RLP is more flexible in that it can operate in any industry-standard PCI host computer and all logic is implemented in reprogrammable nonvolatile logic devices. The RLP is also both more flexible and expandable by virtue of the OSM interface connector.

This work was done by Kenneth B. Winiecki, Jason Dowling, Stephen T. Koubek, and Fred H. Peng of Lockheed Martin and Andrew F. Wolf of RMS for **Goddard Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
GSC-14032

The Automated Fatigue Calculation Program (FATPLUS)

Since it was developed in the late 1980s, the Automated Fatigue Calculation Program (FATPLUS) has consistently demonstrated its ability to predict fatigue life, independently validate proprietary fatigue methodologies, identify fatigue-sensitive parts, and train engineers in predicting fatigue lives. FATPLUS enables its users to create, save, and modify specific stress spectra and properties of materials.

A conservative methodology yields valid estimates of fatigue lives as long as reasonable engineering practices are maintained. However, FATPLUS can do more than this. The program is also a powerful, menu-driven, interactive design software tool for studying and analyzing effects of a spectrum of stresses, effects of changes in design, effects of changes in materials, and changes in concentrations of stresses.

To make FATPLUS into a program that predicts fatigue lives and a very powerful tool for analyzing systems, the developers of FATPLUS accounted for (1) the spectrum of stresses, (2) the number of loadings per stress event, (3) fatigue properties of materials, and (4) safety factors. Of these considerations, safety factors were found to be the largest variables in estimating fatigue lives because safety is affected by (1) constant life reduction, which multiplies total damage or reduces the number of cycles by a constant factor, and (2) statistical reduction, according to which allowable stress is reduced by a percentage based on the known degrees of variability of properties of materials.

When performing a system analysis or study, FATPLUS uses an online or preprogrammed spectrum, which is applied to a materials curve (a complex curve based on the more conservative of constant life reduction or statistical life reduction). Total damage and allowable life are determined from a combination of input from the user and cycles in the input spectrum. Because all users will not have access to corporate or private fatigue data, the developers of FATPLUS provided MIL-HNDBK-5 data on materials.

FATPLUS is therefore a superior program. Since release, this multifaceted program has proved itself strong and adaptable. FATPLUS can be expected to become used widely across private industry and government as users become more aware of all the program has to offer.

FATPLUS is written in FORTRAN for execution on PC-compatible computers.

This work was done by Thomas Minyard and James A. Babb, formerly of Lockheed Electronics and Space Corporation for **Johnson Space Center**. *The software with complete documentation is available from James Babb, Johnson Engineering, telephone (281) 228-7710.*

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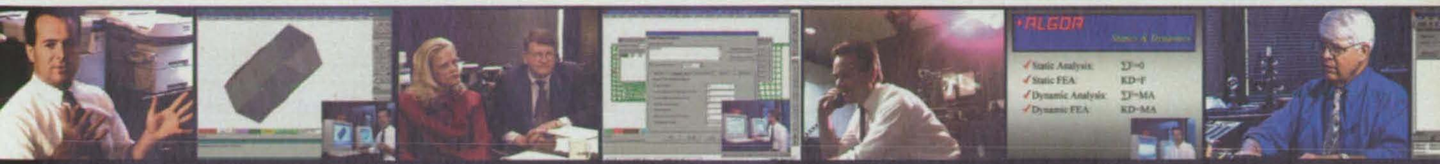

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Materials

Composite-Material Heat Sink for Printed-Circuit Boards

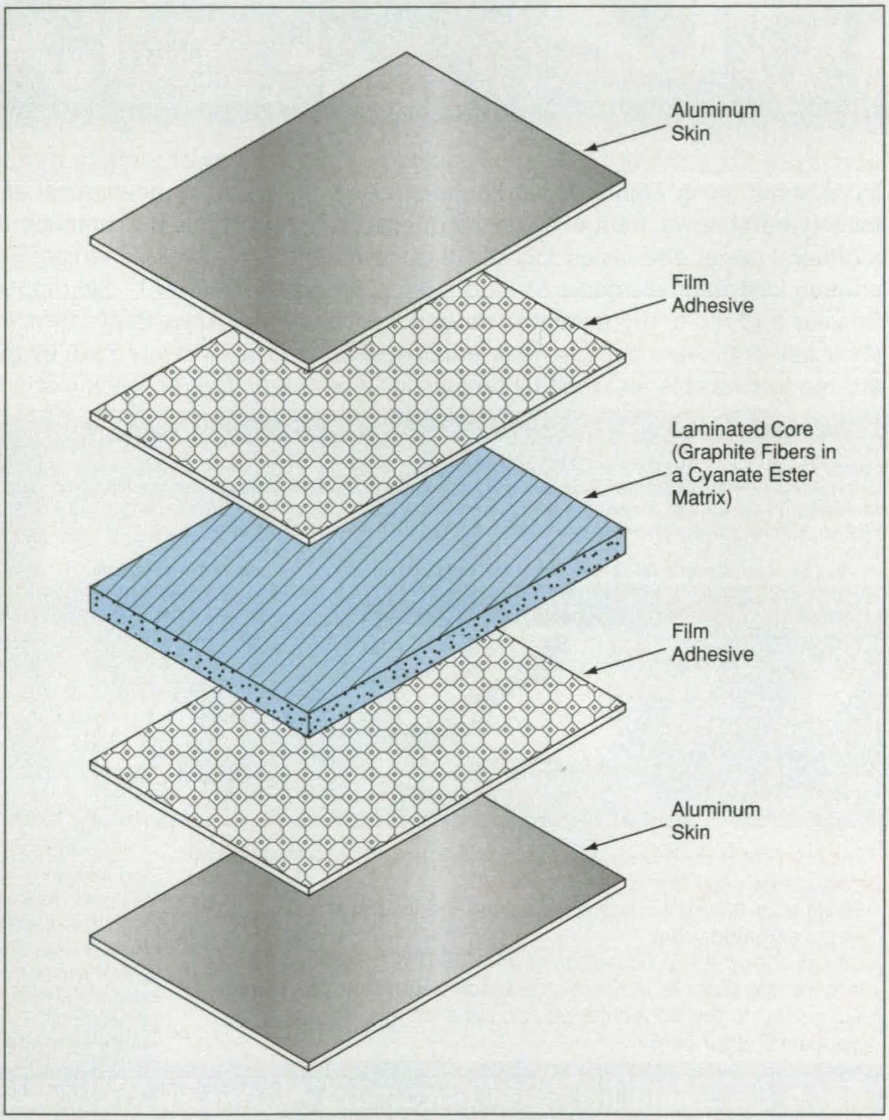
This is a lightweight alternative to an aluminum heat sink.

Goddard Space Flight Center, Greenbelt, Maryland

A laminated composite-material plate has been developed for use as a lightweight heat sink and mechanical support for rigid printed-circuit boards (PCBs) that hold surface-mounted electronic components. This composite-material plate is intended to replace a conventional aluminum heat-sink plate. The aluminum plate weighs 0.63 lb (0.29 kg), whereas the composite-material plate weighs only 0.36 lb (0.16 kg).

An advanced laminated composite is attractive as an alternative to aluminum in several respects:

- The orientations of fibers in the laminae can be selected to tailor the properties of the laminate.
- The bending stiffness of a typical advanced laminated composite material is eight times as great as that of aluminum; this is an important advantage because PCBs that hold surface-mounted components are relatively intolerant to flexing. (The intolerance to flexing arises because flexing can break the beads of solder used for attachment in surface mounting.)
- The density of a typical advanced composite material is two-thirds that of aluminum.
- The coefficient of thermal expansion (CTE) of a quasi-isotropic composite laminate is typically less than one-eighth that of aluminum. The lower CTE of the composite material, in concert with the CTE of the PCB material, promises an increase in fatigue lives of solder joints, and thus increased reliability.
- The effective thermal conductivity of an advanced composite material can be made to exceed that of aluminum; as a result, better heat-sink performance is attainable. As a consequence of better heat-sink performance, heat-generating components can be packed more densely; thus, a greater degree of miniaturization is possible.



The **Composite Heat Sink** was designed to satisfy strength, stiffness, and heat-transfer requirements at least as stringent as those imposed on the design of an aluminum heat sink, but to weigh 43 percent less than the aluminum heat sink does.

The composite-material heat-sink plate (see figure) comprises (1) a quasi-isotropic laminated core of graphite fibers in a cyanate ester matrix and (2) a 0.002-in. (0.05-mm)-thick aluminum skin backed with a film adhesive. The laminated core consists of six laminae; the quasi-isotropy is achieved by stacking each lamina with its fibers at an angle of 60° with respect to those of the adjacent lamina. This fiber orientation was chosen because it optimizes the strength and stiffness characteristics of the laminate. Because the thermal conductivity is greatest along the fibers and it is desired to maximize widthwise thermal conduction in the heat sink, the fibers in the 0° plies are oriented along the width of the heat sink. The aluminum skin is wrapped around the laminated core to provide a continuous ground plane for the PCBs.

This work was done by Jill M. Holz, Lee Niemeyer, and David Puckett of **Goddard Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*
GSC-14142

Reducing Methanol Crossover in CH_3OH-Fuel-Cell Membranes

Perfluorosulfonic acid-based membranes are impregnated with poly(styrene/divinylbenzene).

John H. Glenn Research Center, Cleveland, Ohio

Improved polymer electrolyte membranes for direct methanol fuel cells can be made by impregnating the baseline membrane material with cross-linked polystyrene (a copolymer of styrene and divinylbenzene). The baseline membrane material is a perfluorosulfonic acid-based hydrophilic, proton-conducting ion-exchange polymer sold under the trade name "Nafion". The principal benefit afforded by the impregnation is a reduction in permeability by methanol; this translates to less crossover of methanol in molecular form (denoted "methanol crossover" for short). Methanol crossover is undesired because it wastes fuel and thereby degrades fuel-cell performance.

Membrane Material	Cell Potential (mV) at Current Density of: 100 mA/cm^2	Cell Potential (mV) at Current Density of: 200 mA/cm^2	Crossover, Percent	Electrical Resistance (mΩ) at a Temperature of 60 °C
Baseline	530	450	19.5	7.2
Baseline Containing 8 Weight Percent Cross-Linked Polystyrene	450	290	15.6	10.5

These **Fuel-Cell Performance Figures** were obtained using MEAs containing two different membranes.

To demonstrate this concept, membranes were prepared as follows:

1. Baseline membranes were cut slightly larger than the final size needed for fuel-cell membrane/electrode assemblies (MEAs). The membranes were dried, weighed, and marked for identification.
2. Solutions of 1, 3, 5, and 8 weight percent styrene/divinylbenzene in methyl chloride with 1 weight percent benzoyl peroxide as an activator were prepared for use in impregnation and polymerization.
3. The membranes were placed in the solutions in test tubes, which were then capped to prevent exposure to air.
4. Each capped test tube was heated to a temperature between 60 and 65 °C for 16 or more hours, until polymerization was complete.
5. After cooling to room temperature, the test tubes were cracked to remove the styrenated membranes.
6. Excess polystyrene (the portion not cross-linked with the baseline membranes) was removed by immersing the samples in methyl chloride at room temperature for various times ranging from 1 to 24 hours.
7. The styrenated membranes were sulfonated by immersing them in a solution of $ClSO_3H/CH_3Cl$ for 16 hours.
8. The sulfonated membranes were placed in distilled water at room temperature, the beaker was covered, and the water was brought to a rapid boil. Samples of the water were cooled to room temperature and tested for Cl^- ions by use of one or two drops of $AgNO_3$ solution. In each case, if a positive result was found, the membranes were removed and placed into another, previously heated beaker of distilled water. This was repeated until the test for Cl^- ions yielded a negative result.

Both baseline membranes and membranes prepared as described above were tested to characterize them with respect to ion-exchange capacity, water content, cell resistance, permeability by methanol, and proton conductivity. The best one of the prepared membranes was fabricated into a complete MEA, using Pt/Ru anode and Pt black cathode catalysts. An MEA was also made from a baseline membrane. Both MEAs were then tested in a fuel cell. The results of the test (see table) show decreased methanol crossover in the case of the styrenated membrane. The results also show decreased fuel-cell performance in this case. The decrease in performance has been tentatively attributed to incompatibility of the styrenated membranes with the electrode structures and bonding conditions, which were optimized for the unstyrenated membranes. The implication is that it should be possible to recover lost fuel-cell performance by optimizing the electrode structures and bonding conditions for styrenated membranes.

This work was done by J. Kosek, M. Hamdan, and A. B. LaConti of Giner, Inc., for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135.

Refer to LEW-16669.

Mechanics

Inflatable Wing Leading Edges for High Lift and Deicing

The incidence of stall accidents could be reduced.

John H. Glenn Research Center, Cleveland, Ohio

Computational simulations and wind-tunnel tests have demonstrated the feasibility of using inflatable boots on the leading edges of airplane wings, both as devices to increase lift and as pneumatic deicing actuators. Assuming success in further research and development, the first applications would likely occur as retrofits to single- and twin-engine airplanes in general aviation (GA). Later, corporate and commuter turboprop airplanes would be included. The eventual incorporation of these boots into new GA airplane designs would be even more desirable because the boots could be integrated with overall wing structures to provide laminar flow in cruise.

The model used in the wind-tunnel tests and as the basis for the computational simulations was a standard airfoil (type 63-212 of the National Advisory Committee for Aeronautics) with a faired circular-arc boot installed on the leading edge (see Figure 1). A boot of this type comprises front and rear cells. The front cell is shaped so that when it is inflated, its exposed leading-edge surface is nominally a portion of a circular cylinder. The rear cell serves as a fairing; it is vented to the atmosphere instead of inflated, and it is formed by attachment between a tangent line on the front cell and a line on the bottom surface of the airfoil.

Faired circular-arc boots for the wind-tunnel model were made of a standard deicing-boot material, and two different designs called "inlaid" and "overlaid" were tested. In the tests, inflation of both boots resulted in significant increases in the maximum coefficient of lift and the angle of the stall break (see Figure 2). Results of preliminary calculations based on the data from these tests suggest that it should be possible to achieve substantial increases in gross weight and reductions in stall speeds by use of faired circular-arc boots.

The use of inflatable leading-edge boots on GA airplanes would enable operation under known icing conditions and would thereby reduce the incidence of weather-related flight delays. High-lift features could be incorporated into deicing systems with very small increases in weight. Inflation of the boots for high lift would greatly extend angles of attack for maximum lift and would broaden the peaks of lift-vs.-angle-of-attack functions, thereby helping to prevent stall accidents.

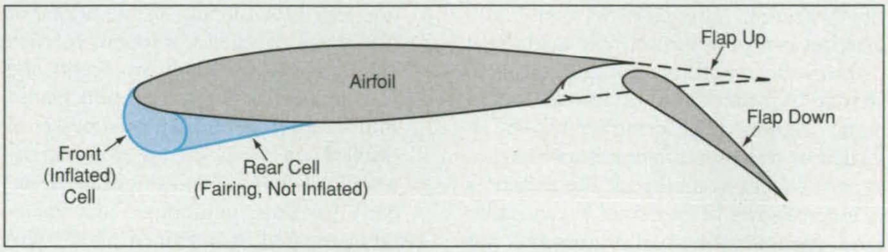


Figure 1. An **Inflated Faired Boot** installed on the leading edge of an airfoil can be used to increase lift and/or as a deicing actuator. A model with this configuration was used in wind-tunnel tests.

This work was done by Kenneth G. Wernicke and Rodney K. Wernicke of Sky Technology Vehicle Design & Development Co. and Norbert A. Weisend, Jr., Consultant, for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

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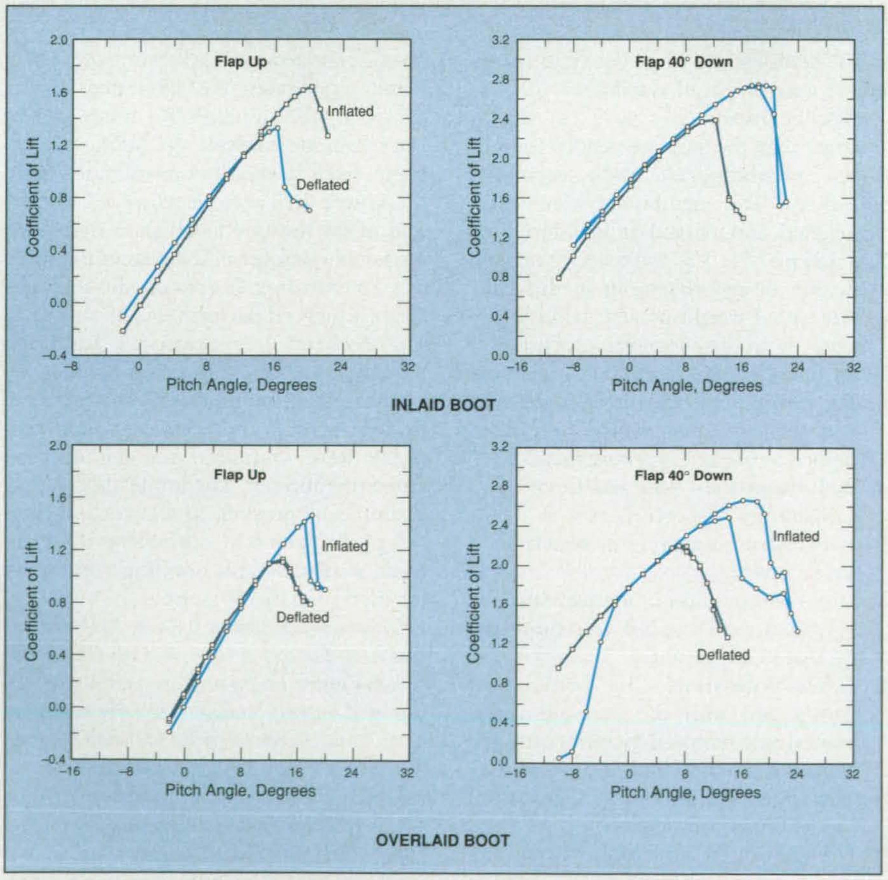

Figure 2. **Maximum Coefficients of Lift and Angles of Stall Breaks** were increased by inflation of boots, in both the flaps-up and flaps-down conditions.

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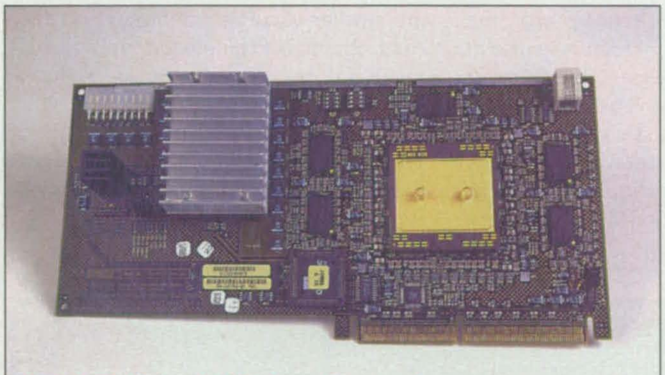

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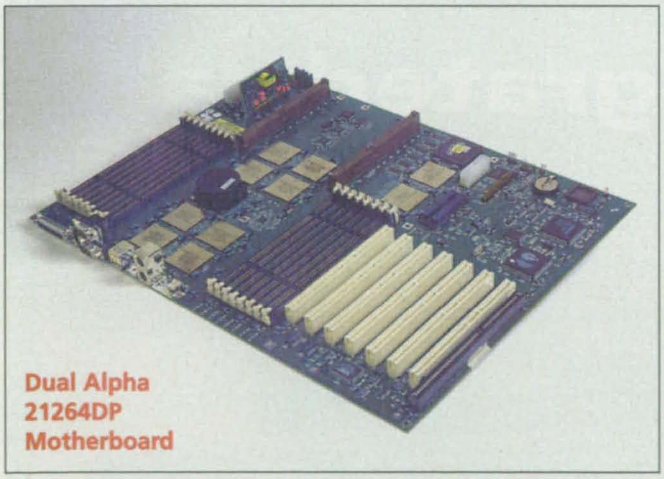

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Microway hardware products have always been popular with government, industry, and university researchers. Our i860 powered cards were used to search for oil, improve MRI resolution, do air flow studies on jet engines, and help the NASA SETI project search for extraterrestrial life. Microway high-end Alpha and Pentium workstations are currently in use throughout the US in major universities and research organizations like NASA, NIST, NIH, Lincoln Laboratory, Smithsonian, and CDC.

Company History

Microway was founded in 1982 to help scientists and engineers take advantage of the IBM PC. Our first product was a library, which made it possible to use an 8087 in a PC. We bundled our libraries with 8087s and became one of Intel's largest customers.

Our hardware products included PC accelerators, coprocessor cards, and motherboards. In 1986, we introduced the first 32-bit Fortran to run on an Intel PC. The first PC to hit a megaflop used a Microway/Weitek coprocessor driven by NDP Fortran. Over the years, NDP Fortran has been used to port hundreds of popular mainframe applications, including MATLAB and ASPEN, to Intel-based PCs.

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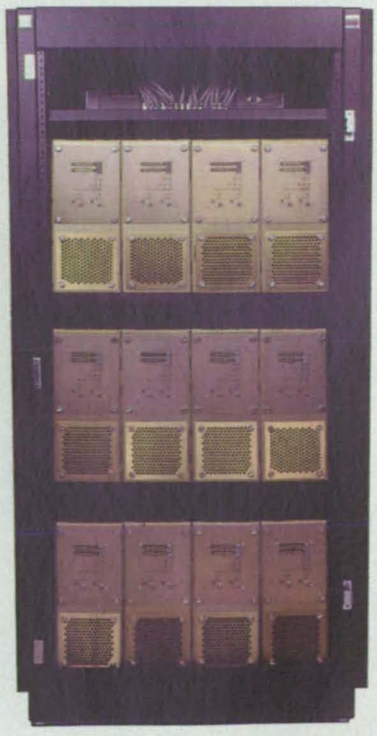
Microway 24 Node Linux Beowulf Cluster



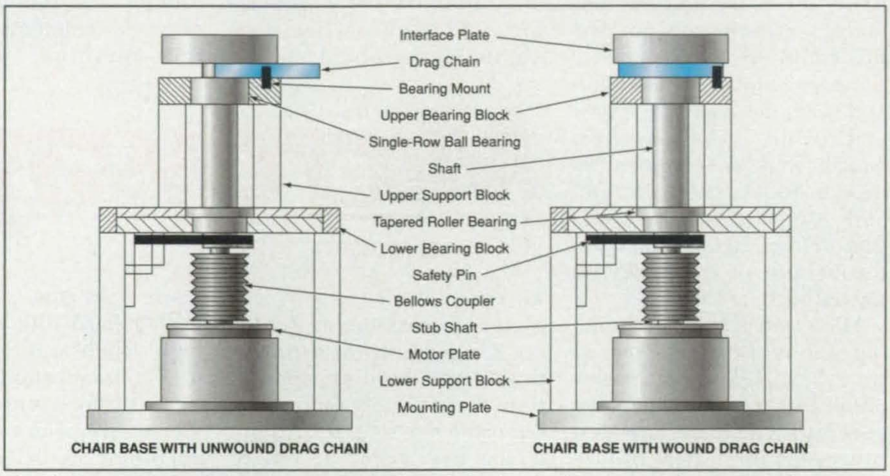
Bushing-Mounted Drag Chain

A drag chain can be wrapped to a smaller radius than was previously possible.

Lyndon B. Johnson Space Center, Houston, Texas

The figure illustrates a chair-base mechanism with a bushing-mounted drag chain. The bushing-mount design provides for one end of the drag chain to be free to pivot; this provision makes it possible to wrap the drag chain to a radius smaller than that achievable in mechanisms previously designed for the same purpose. The utility of mechanisms like this one lies in applications in which rotation of machinery involves significant turning radii, so that bending of cables that run through drag chains involve relatively tight arcs.

The bushing-mounted drag chain contains cables and wires for actuating controls on a mechanical chair that can be rotated through 280° by use of the chair-base mechanism. In addition to being bushing-mounted, the drag chain is bearing-mounted on the upper bearing block; because of this, the bend radius of the chain varies with rotation of the chair in such a way as to maintain an overall compact system. This design feature reduces the amount of external floor space needed for a given length of drag chain and limits the overall length of the drag chain.



The **Chair-Base Mechanism** is connected to a drag chain via a bushing mount that reduces the amount of space needed to accommodate the drag chain.

The chair-base mechanism with the bushing-mounted drag chain is in use at the Dexterous Robotics Laboratory at Johnson Space Center. The potential of the economical and efficient design of this mechanism has not yet been fully realized; future applications could occur in Hurco (or equivalent) drill presses, any similar rotating machinery in which drag chains are employed, and mechanisms for rotating gantry assemblies or other machinery.

This work was done by Myron A. Diftler of Lockheed Martin Corp. for **Johnson Space Center.** *No further documentation is available.* *MSC-22732*

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Sony Precision Technology America, Inc. 20381 Hermana Circle, Lake Forest, CA 92630

SONY

Improved Urine Preservative

This solution combines antibacterial and antioxidant properties.

Lyndon B. Johnson Space Center, Houston, Texas

An improved solution for preserving samples of urine has been formulated. This solution preserves a much broader spectrum of analytes in urine than do other urine-preservative solutions heretofore in use by NASA, and is safe for use by humans. When this solution is used, (1) refrigeration of urine samples is not necessary for preserving them and (2) the solution does not alter the pH values of the samples — two important considerations for collecting and storing urine samples in outer space. By eliminating the need to ship frozen samples, this preservative will enable the collection of urine samples — not only in outer space but also in terrestrial remote settings where it was previously not feasible.

Limits on overall available space and power aboard spacecraft include severe limits on available space for storing frozen biological fluids. Researchers at Johnson Space Center hoped to identify a way of preserving urine analytes at ambient temperature for long times to lessen the effects of these limits on biomedical research and monitoring of crew health. What they formulated is the present urine preservative, called "CPG," which is a solution that comprises equal parts of chlorhexidine gluconate and n-propyl gallate. CPG eliminates or reduces the primary causes of destruction of analytes in urine; these causes are bacterial contamination and oxidation. CPG does this without altering the pH of the urine. These characteristics make CPG an excellent candidate for use not only in outer space but also in the commercial medical field on Earth.

Chlorhexidine gluconate is a water-soluble, bactericidal compound used commercially as a topical anti-infective agent. N-propyl gallate, a commercial food additive, is an antioxidant. The Food and Drug Administration has ruled that both compounds are safe for use by humans at the concentrations necessary to maintain the integrity of urine samples.

To make CPG, one first prepares 20-percent solutions of n-propyl gallate and chlorhexidine gluconate, then mixes these solutions in equal parts. The resulting CPG solution is placed into aliquot tubes to yield a final concentration of 0.4 milligram of CPG per milliliter of urine.

Researchers tested CPG with 17 urine analytes during 12 months, using two separate pooled samples. Unpreserved aliquots from each pool were stored at a temperature of −70 °C as baseline samples. Both preserved and unpreserved aliquots from each pool were also stored at room temperature. Analytes were measured on days 1, 14, and 28 for the first month and then once a month for the next 11 months. The table gives the results of this study. The bold text within the table indicates the instances in which CPG provided extended room-temperature stability.

This work was done by Scott Smith of **Johnson Space Center** *and Jeannie Nillen of Krug Life Sciences, Inc.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-4871. Refer to MSC-22695.

Analyte or Property	Duration of Stability (Compared to That of Unpreserved Urine Stored at –70° C)	
	Room Temperature	Room Temperature (Preserved by CPG)
Urea	28 days	**12 months**
Ammonia	Unstable	**14 days**
Calcium	Unstable	**3 months**
Creatinine	Unstable	Unstable
Sodium	7 months	5 months
Potassium	3 months	**7 months**
Chloride	4 months	4 months
Osmolality	Unstable	Unstable
3-Methylhistidine	6 months	3 months
Aldosterone	Unstable	**14 days**
Cortisol	Unstable	**2 months**
Cyclic Guanosine-5'-Monophosphate	Unstable	**7 months**
Melatonin	5 months	**8 months**
Total Nitrogen	2 months	**3 months**

Preliminary Data indicate that CPG preserves a number of urine analytes during prolonged storage at room temperature.

Noninvasive Determination of Pressure in Cerebrospinal Fluid

Spinal taps would no longer be necessary.

NASA's Jet Propulsion Laboratory, Pasadena, California

A technique for noninvasive determination of the pressure in the cerebrospinal fluid (CSF) has been proposed. This technique would involve two main steps: First, an optical coherence tomographic scanner would be aimed into an eye and used to image the optical disk (see figure). Next, the resulting tomographic imagery would be digitized and processed to determine the thickness of the neural fiber layer, which thickness is known to increase with the CSF pressure.

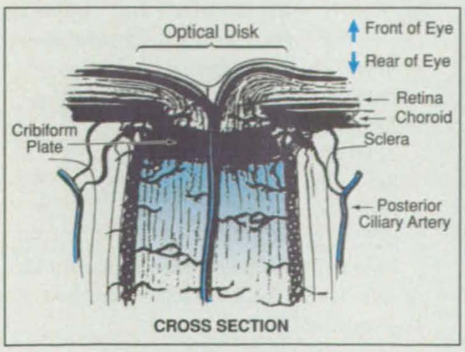
Heretofore, the spinal tap has been the standard technique for measuring the CSF pressure (also known as the intracranial pressure or "ICP"). Spinal taps are painful, dangerous, and expensive. The proposed technique could make it unnecessary to perform spinal taps.

Papilledema — swelling of the optic-nerve axons in the optic disk — is known from previous studies to be associated with an increase in the intracranial pressure beyond the normal limit of approximately 14 mm of Hg (about 1.9 kPa). The neural fiber layer can swell to as much as 20 times its normal thickness within hours after the onset of elevated intracranial pressure.

Papilledema can be seen through an ophthalmoscope. Stereoscopic fundus photography and optic-nerve-head analysis also reveal aspects of papilledema. The common limitation of these previously developed optical techniques is that they depend on changes in surface topography. The proposed version of optical coherence tomography would measure the thickness of the neural fiber layer regardless of changes in surface topography, and should be capable of revealing swelling of axons earlier than do the previously developed optical techniques.

By use of a previously constructed optical coherence tomographic scanner, it has been found that the thickness of the neural fiber layer in normal individuals varies by no more than 3 μm. This instrument has also been found capable of revealing early thinning of the neural fiber layer associated with glaucoma. Thus, it has been reasoned, it should be possible to use optical coherence tomography to measure early neural-fiber-layer swelling associated with intracranial hypertension. If the instrument could be modified to achieve a tenfold refinement of its resolution, then the instrument would be correspondingly more sensitive as an indicator of intracranial pressure. The modified instrument could be used in research on the sequence of events in papilledema because it could also provide information on deep and surface changes in the optic disk, flows of blood in veins and arteries, and shifts in the spectral reflectance of the optic disk.

This work was done by Mark S. Borchert and James L. Lambert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Bio-Medical category. NPO-20079*



The **Optic Disk** (known popularly as the "blind spot") is the spot where the fibers of the optic nerve leave the eye. The thickness of the neural fiber layer in the optic disk increases with the intracranial pressure. According to the proposal, this thickness would be determined optically to obtain an indirect indication of the intracranial pressure.

Primers for Amplifying CMV DNA in Body Fluids and Tissue

A novel set of primers enables high-volume, rapid, inexpensive viral diagnostic testing.

Lyndon B. Johnson Space Center, Houston, Texas

A novel set of primers has been developed for use in a polymerase chain reaction (PCR) to amplify the deoxyribonucleic acid (DNA) of cytomegalovirus (CMV). The purpose of this development is to enable faster, more sensitive detection of CMV virus infecting body fluids and tissues.

Each year, in the United States, an estimated 40,000 infants are infected congenitally with CMV, which is a member of the herpesvirus family. CMV is the most common congenital viral infection in humans, and it is the leading infectious cause of mental retardation and nonhereditary sensorineural deafness. Studies show that CMV can survive from 2 to 48 hours in saliva and on environmental surfaces. Healthy adults usually experience unrecognized mild infections of this latent virus. For spaceflight crews, the pre-spaceflight quarantine period does not lessen the infectious-disease risks associated with latent viruses. Resulting viral illnesses can seriously affect the health of a crew.

The tissue-culture methods used heretofore for detecting CMV infections are labor-intensive, are subject to variability among technicians, lack sensitivity and specificity, and are time-consuming (taking 4 to 21 days in each case). The present PCR method with the novel primers overcomes these deficiencies of tissue-culture methods. The first primer — the sense strand — is a 21-base-pair oligonucleotide; the second primer — the antisense strand — is an 18-base-pair oligonucleotide. The use of these primers makes it possible to detect CMV infections directly from specimens of urine, saliva, blood, cerebrospinal fluid, and feces. These primers and the PCR method satisfy requirements with respect to preparation of specimens, sensitivity relative to traditional methods, and clinical significance of results. Applications also include detection of relapse of infection and testing the effectiveness of the antiviral therapy.

The development of this set of primers to amplify viral DNA by PCR offers a rapid, high-volume, and less expensive means (relative to tissue-culture methods) of viral diagnostic testing. Patients who have AIDS or cancer, transplant recipients, and others who are susceptible to CMV infections would receive the most benefit from this method of rapid detection.

This work was done by Duane L. Pierson of **Johnson Space Center** *and Raymond P. Stowe of KRUG Life Sciences, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Bio-Medical category.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457(f)], to KRUG Life Sciences, Inc. Inquiries concerning licenses for its commercial development should be addressed to

Raymond P. Stowe
KRUG Life Sciences, Inc.
1290 Hercules Drive
Suite 120
Houston, TX 77058
(281) 212-1200

Refer to MSC-22694, volume and number of this NASA Tech Briefs *issue, and the page number.*

Physical Sciences

GFSSP — Program for Analyzing Flows in a Complex Network

Marshall Space Flight Center, Alabama

The Generalized Fluid System Simulation Program (GFSSP) version 2.01 is a general-purpose computer program for analyzing steady-state and time-dependent flowrates, pressures, temperatures, and concentrations in a complex flow network. The program is capable of modeling phase changes, compressibility, mixture thermodynamics, and external body forces, such as gravity and centrifugal.

The program contains subroutines for computing "real fluid" thermodynamic and thermophysical properties for 12 fluids. The fluids are helium, methane, neon, nitrogen, carbon monoxide, oxygen, argon, carbon dioxide, fluorine, hydrogen, water, and kerosene (rocket propellant 1). The program also provides the options of using any incompressible fluid with constant density and viscosity.

Seventeen different resistance/source options are provided for modeling momentum sources or sinks in the branches. These options include: pipe flow, flow through a restriction, noncircular duct, pipe flow with entrance and/or exit losses, thin sharp orifice, thick orifice, square edge reduction, square edge expansion, rotating annular duct, rotating radial duct, labyrinth seal, parallel plates, common fittings and valves, pump characteristics, pump power, valve with a given loss coefficient, and a Joule-Thompson device.

GFSSP employs a finite volume formation of mass, momentum, and energy conservation equations in conjunction with the thermodynamic equations of state for real fluids. Mass, energy, and specie conservation equations are solved at the nodes; the momentum conservation equations are solved in the branches. The system of equations describing the fluid network is solved by a hybrid numerical method that is a combination of the Newton-Raphson and successive substitution methods.

The computer program has three major parts. The first part consists of the subroutines for the preprocessor. The preprocessor allows the user to interactively create the flow network model consisting of nodes and branches. All of the input specifications, including the boundary conditions are specified through the preprocessor. The second major part of the program consists of the subroutines that provide the initial conditions and then develop and solve all of the conservation equations in the flow network. The third part of the program consists of the thermodynamic-property programs that provide the necessary thermodynamic- and thermophysical-property data required to solve the resulting system of equations.

GFSSP has been developed, tested, and documented by Sverdrup Technology for Marshall Space Flight Center (MSFC). GFSSP is currently being used at MSFC, and its predictions showed good agreement when compared with test data. GFSSP runs on an IBM-PC compatible computer under Windows 95 and Windows NT and under UNIX operating systems.

This program was written by Alok Kumar Majumdar, John W. Bailey, Paul Alen Schallhorn, and Todd E. Steadman of Sverdrup Technology for **Marshall Space Flight Center.** *NASA seeks companies interested in licensing this technology to make it available as a commercial product or for their own use. Licensing inquires should be directed to Larry Gagliano, MSFC Software Release Authority at (256) 544-7175 or larry.gagliano@msfc.nasa.gov.*

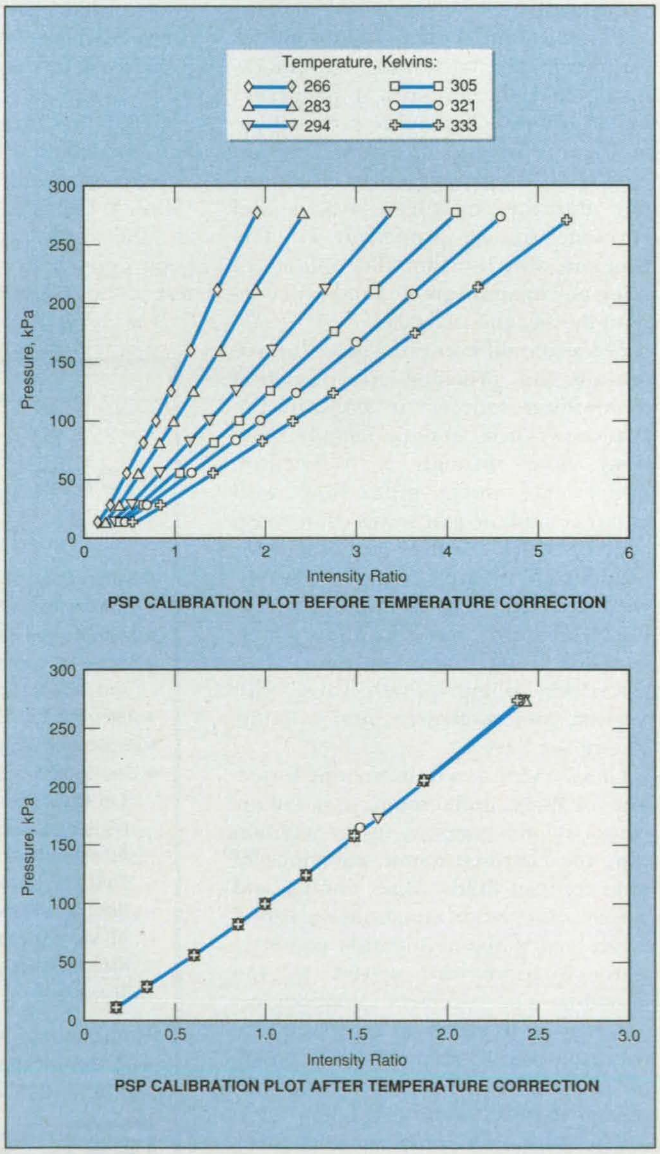
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Marshall Space Flight Center; (256) 544-0021. Refer to MFS-31303.

Temperature Correction for Pressure-Sensitive Paint

One can extract pressure data from partially-temperature-dependent luminescence data.

John H. Glenn Research Center, Cleveland, Ohio

A temperature correction has been developed to enable the extraction of pressure images and corresponding pressure data from images of photoluminescence of pressure-sensitive paints (PSPs). These paints are used on wind-tunnel models for mapping surface pressures associated with supersonic flow fields. PSP has been successfully used in wind-tunnel test ranging from 60 mi/h (97 km/h) to the supersonic range >3. The photoluminescence of an ideal PSP would depend on pressure only, but the photoluminescence of a real PSP depends on temperature also. In order to extract a pressure image, one must be able to invert the luminescence-image data on the basis, not only of the pressure dependence but also of the temperature dependence and of the distribution



A Family of Calibration Curves clearly depicts the effect of temperature. The temperature correction collapses the family of curves to a single curve, so that it suffices to perform the pressure calibration at one temperature only.

of temperature on the painted surface; in other words, one needs to incorporate a temperature correction into the pressure calibration of the luminescence of the paint.

A PSP contains luminophores (basically, dye molecules), that luminesce in a suitable wavelength range in response to photoexcitation in a shorter wavelength range. The photoluminescence is quenched by oxygen at a rate proportional to the partial pressure of oxygen and thus proportional to the pressure of air. As a result, the intensity of photoluminescence varies inversely with the pressure of air, and the basic equation for calibrating a photoluminescence image is the following:

$$P/P_{REF} = A + BI_{REF}/I,$$

where P is the unknown pressure that one seeks to determine under the test condition (e.g., in the presence of wind), P_{REF} is the pressure under a reference condition (e.g., in the absence of wind), I_{REF} is the intensity of luminescence under the reference condition, and I is the intensity of luminescence under the test condition. The need for temperature correction arises because A and B depend on temperature.

The temperature correction is based on the experimental observation that in the above equation for P/P_{REF}, the combined effects of pressure and temperature can be expressed by use of a corrected intensity ratio; that is,

$$P/P_{REF} = A + B[I_{REF}/I]_{CORR}$$

The corrected intensity ratio is given by

$$[I_{REF}/I]_{CORR} = (I_{REF}/I)(CT^2+DT+E),$$

where T is the absolute temperature and C, D, and E are constants obtained via a least-squares best fit to calibration data acquired by use of a PSP test rig. Alternatively, calibrations usually use a combination of PSP calibration cell data and conventional pressure taps. The taps are used as truth points to help set an absolute level since this is a delta (change) pressure measurement and the largest error is typically the absolute pressure level. The figure presents calibration plots for a PSP, as they appear before and after the application of the temperature correction.

Of course, in order to be able to apply the temperature correction to PSP images of a model in a wind-tunnel test, one must know the temperature distribution on the model during the test. A temperature image can be acquired by coating the model with a temperature-sensitive paint (TSP) and testing it under the same conditions as those used when it is coated with PSP. Alternatively, this can help for a uniform temperature change but does not help for correcting for temperature gradients on the test article. Large temperature gradients exist on thermally conductive models that need full field temperature measurements to fully compensate for the temperature sensitivity of PSP.

This work was done by Timothy J. Bencic of **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to:

NASA Glenn Research Center
Commercial Technology Office
Attn: Steve Fedor
Mail Stop 4–8
21000 Brookpark Road
Cleveland, Ohio 44135.

Refer to LEW-16915.

Further Developments in Web Interactive Training

Displays, simulations, and quizzes are customized for each trainee.

John F. Kennedy Space Center, Florida

Three innovative computer programs for training and testing personnel at Kennedy Space Center have been developed under the aegis of the Web Interactive Training (WIT) project. The WIT project exploits the capabilities afforded by the Internet and by state-of-the-art multimedia data-presentation techniques. The World Wide Web is used to deliver training from server computers to client desktop computers on demand. Training can involve multimedia data of various types (text, audio, graphics, and animated video images). Training can be interactive, enabling trainees to tailor lessons to their individual needs; a trainee can select a lesson or segment any time, anywhere, and can repeat a segment as many times as necessary. Interactivity can also be exploited to provide for testing and recording of a trainee's progress.

One of the innovative programs provides a simulation of the International Organization for Standardization (ISO) 9000 certification process. By use of standard Hypertext Markup Language (HTML) pages and forms, the program creates an interactive system for ISO 9000 training. The client-side requirements for using the system are minimal; any popular Web-browser software can be used.

Each time the simulation is run, the events are slightly different. That is to say, the HTML pages are not static like ordinary Web pages; they are generated dynamically to create a more realistic representation of the simulated process.

The code on the server is highly object-oriented. The system can be expanded and new functionality can be added without disrupting the system. The user-interface part of the program is separate from the application part of the program; because of this architecture, new user interfaces can be created without modification of the main application code. Similarly, rules of a simulation can be changed without affecting the user interface.

Another of the innovative programs generates tests that are integral parts of a training course on techniques of nondestructive evaluation. The course is presented to each trainee in modules. Each module includes (1) a video

overview of a technique in action, (2) text and graphics that explain the theory and application, (3) an interactive simulation of an application of the technique (generated by the program described in the next paragraph), and (4) a quiz generated by random selection of questions from a data base of questions. Immediately after submitting answers, the trainee is presented with the test score, a brief explanation of the correct answers, and a link to the place in the course where the topic was covered. It is more difficult for a student to cheat because the program generates a different version of the quiz for each student and makes it impossible for any given student to take the same version of the quiz twice.

Still another innovative program is the one that generates the interactive simulations in the training modules. Each simulation is designed to give practice in one of a number of nondestructive testing processes: visual inspection, liquid-penetrant testing, magnetic-particle testing, eddy-current testing, leak testing, ultrasonic testing, or radiography. The simulations incorporate learning by example, repetition, and positive feedback. For example, in a simulation of the use of computed x-ray tomography of a solid cylinder, the student moves a scanner head along the cylinder while observing the scan on a simulated computer screen. Upon identifying a potential discontinuity, the trainee clicks on it; if the identification is correct, the simulation is immediately reset with the discontinuity scattered randomly to one or more different position(s). The trainee can repeat the simulation as many times as needed.

The advanced technology features of the WIT project contributed to the project winning a Gold Award in the 1997 multimedia and Internet Training Awards.

This work was done by Roger Wright, Thomas Brubaker, Angela Smibert, David Metcalf, and Tracy Bierman formerly of I-NET, Inc., for **Kennedy Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category or visit the WIT Web site at http://wit.ksc.nasa.gov.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373, or for information regarding commercialization of this technology contact: Merrimac Interactive Media Corporation, 200 Willard, Suite 1A, Coca, FL, 32922, telephone: (407) 638-4118. Refer to KSC-11962.

Developmental Software for Exploiting Hyperspectral Imagery

Evolutionary computing techniques are used.

American GNC Corporation, Chatsworth, CA

A unique state-of-the-art process for exploiting hyperspectral satellite imagery, based on evolutionary computing methods, has been developed and a proof-of-concept demonstration has been conducted. This development is projected to lead to several important commercial products, including a fully integrated, high-payoff, user-friendly software package — the Integrated Hyperspectral Imagery Analysis Toolbox. This software would be capable of end-to-end processing of industrial and governmental hyperspectral satellite image data with extensions to several popular commercial software products like ENVI from Research Systems, Inc., and ESRI's ArcView Geographical Information System. The development of the end product will focus on accurate detection and identification of natural and artificial materials and objects, the use of large libraries of laboratory reference data, and ease of use. Potential commercial applications include assessment of crops (including estimation of crop yields), exploration for minerals and oil, planning of military missions and automated identification of military targets, urban planning, environmental assessment, and search-and-rescue operations.

The process effected by the proof-of-concept version of the software is the following: A spectral band signature is extracted from a hyperspectral satellite image and filtered to remove noise. It is then normalized to remove global gain differences. Next, an artificial neural network identifies those categories of objects and materials that correlate with the sensed data. The categories are expressed as orthonormal feature vectors derived from training signatures that were preprocessed in a manner similar to that of the sensed data. Finally, an evolutionary algorithm processes the output of the artificial neural network, detects the relevant materials, and estimates the amounts of the materials.

A computer program that performs an end-to-end computational simulation of the process has been developed. This program is capable of accepting real hyperspectral image data, performing the requisite processing on the data, and providing a graphical display of the results. The ENVI software, which provides a computational environment for rapid prototyping of other software, was used to facilitate the development of the simulation program. In the simulation, high performance in detecting and identifying materials in the terrain, including materials with spectrally mixed signatures, was demonstrated. Terrain-classification maps were generated, illustrating how signature variations can be handled, given terrain variations. Also demonstrated was an excellent capability to discriminate between strongly similar, but different, types of vegetation.

Further efforts are planned to accomplish the following:

- Development and execution of a data-collection plan (which would include the collection of ground-truth data) involving commercial and governmental sensors.
- Extension of public-domain atmospheric-compensation methods to include terrain topography.
- Updating of algorithms for improved performance against mixed spectral signatures, including signatures of unknown materials.

This work has been and will be undertaken by the **American GNC Corporation**, *9131 Mason Avenue, Chatsworth, CA 91311, an SBA 8(a) certified Small Disadvantaged Business concern, as part of a NASA Small Business Innovation Research (SBIR) project monitored*

by **Stennis Space Center**. *The NASA SBIR Contract Number is NAS13-98208; Topic: 97-1 14.06; Topic Title: Measurement and Enhancement of Satellite Scientific Data Quality and Applicability. For further information, contact Dr. Ching-Fang Lin, American GNC Corporation, at tel: (818) 407-0092, fax: (818) 407-0093, or e-mail: cflin@americangnc.com. SBIR0007*

Expert System To Develop Job Standards

John F. Kennedy Space Center, Florida

The Job Standards Development System is a user-friendly expert system that (1) helps users select an appropriate work measurement methodology to develop job standards (or the less formal job time estimates) and (2) leads the users through the steps necessary to use a work time estimating technique to develop job standards for long-duration, low-repetition work. The computer program comprises three parts, the first being a system-administration subprogram, in which an administrator sets values of parameters that are not changeable by a job standards developer. The second part is a subprogram that assists the job standards developer in the selection of an appropriate work measurement technique. The third part supports the application of a work time and resource requirement estimating technique that relies on domain expertise to describe human work, collects work time and resource requirement data from the domain expert, and computes a job standard. The program is expected to be useful for the management of organizations devoted to performing functions consisting of long-duration, low-repetition work. Illustrations of this type include facility and equipment maintenance and the knowledge work of service firms and federal, state, and local governments. The program is written for use with the Windows operating systems on IBM PC and compatible computers.

This work was done by Neal F. Schmeidler and John D'Avanzo of OMNI Engineering & Technology, Inc., for **Kennedy Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to: Neal Schmeidler, OMNI Engineering & Technology, 7921 Branch Drive, Suite 530, McLean, VA 22102. Telephone No: (703) 827-8976. Web site: www.omni-engineering.com

Refer to KSC-12072, volume and number of this NASA Tech Briefs *issue, and the page number.*

Books & Reports

Update on Electrolytes for Low-Temperature Lithium Cells

A report presents results of research on carbonate-based electrolytes to improve the low-temperature-performances of lithium-ion rechargeable electrochemical cells. The loss of performance with decreasing temperature is attributable largely to a decrease of ionic conductivity and the increase in viscosity of the electrolyte. What is needed to extend the minimum operating temperature from 20 °C down to −40 °C is a stable electrolyte solution with relatively large low-temperature conductivity, relatively small low-temperature viscosity, a large electric permittivity, adequate coordination behavior, and appropriate ranges of solubilities of liquid and salt constituents.

This work was done by Marshall Smart, Ratnakumar Bugga, Chen-Kuo Huang, and Subbarao Surampudi of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Rechargeable Lithium-Ion Cells with Improved Low-Temperature Performance with Novel Carbonate-Based Electrolyte," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category. NPO-20407*

Techniques for Controlling Buoyancy of Balloons on Titan

A report discusses alternative techniques for controlling the buoyancy, and thus the altitude and landings, of a balloon-borne instrumentation system that would be launched to explore the moon Titan of the planet Saturn. Some of the techniques are based on established concepts of heating or cooling gases in balloons. One technique involves the acquisition or release of gaseous ballast by compressing and liquefying atmospheric gas into a pressure vessel (or allowing the liquefied gas to vent back to the atmosphere); a similar technique involves compressing atmospheric gas into (or releasing it from) a bladder. The simplest and preferred buoyancy technique is to use controlled heating of the helium balloon by means of diverting waste heat from a radioisotope thermoelectric power source.

This work was done by Jack Jones and Jay Wu of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "Preliminary Study of Titan Balloon Buoyancy Techniques," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category. NPO-20656*

Studies of Interaction Impedance in a TWT Helix

Two reports present further developments in the subject of "Computation of Characteristics of a Helical TWT Slow-Wave Circuit" (LEW-16571), *NASA Tech Briefs*, Vol. 22, No. 4 (April 1998), page 54. The subject is computation, by use of the MAFIA (Solution of **MA**xwell's Equations by the **F**inite-**I**ntegration-**A**lgorithm) computer program, of the cold-test electromagnetic characteristics of the helix and surrounding structures in the slow-wave circuit of a traveling-wave tube (TWT). Special attention is given to the on-axis electron-beam/slow-wave interaction impedance, which cannot be measured directly. Heretofore, this impedance has been determined indirectly from cold-test measurement of the change in the resonance frequency resulting from the introduction of a dielectric rod on the axis.

This work was done by James A. Dayton, Jr., of **Glenn Research Center** *and Carol L. Kory of Analex Corp. To obtain copies of the reports, "Computational Investigation of Experimental Interaction Impedance Obtained by Perturbation for Helical Traveling-Wave Tube Structures," and "Accurate Cold-Test Model of Helical TWT Slow-Wave Circuits," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16881.

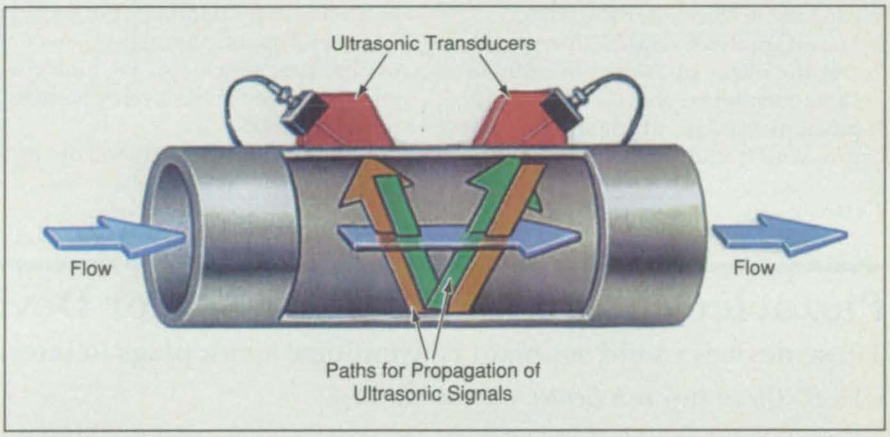
Special Coverage: Sensors

Nonintrusive Flow-Measurement System

Flow is measured ultrasonically, from outside the pipe.

John F. Kennedy Space Center, Florida

A nonintrusive flow-measurement system based on ultrasonics has been developed to replace a system based on turbine flowmeters. A turbine flowmeter must be mounted in line with a pipe; this raises the possibility of leakage at the flowmeter/pipe joints, and the flowmeter unavoidably perturbs the flow. Moreover, a turbine flowmeter is vulnerable to mechanical malfunction and can be vulnerable to corrosion or clogging, depending on the nature of the fluid. In contrast, the ultrasonic flow-measurement system does not contain any rotating or sliding mechanisms that could fail, and does not involve any penetration of the pipe, so that the flow is not perturbed and there is no risk of leakage, clogging, or corrosion.



Transit Times of Ultrasonic Signals propagating upstream and downstream between the two transducers are measured. The flow velocity is calculated from the difference between the transit times.

The nonintrusive ultrasonic flow-measurement system includes two ultrasonic transducers that are clamped on the outside of a pipe, at positions upstream and downstream from each other (see figure). Each transducer serves as both a transmitter and a receiver of ultrasound. The transducers are connected to electronic signal-generating and -processing circuits and a digital data-acquisition and -processing subsystem.

The basic measurement principle is straightforward: ultrasonic signals are transmitted in both directions between the transducers. The intervals between transmission and reception (transit times) are measured for signals propagating both upstream and downstream. When the fluid in the pipe is not flowing, the transit times in both directions are equal. When the fluid is flowing, the upstream transit time exceeds the downstream transit time. The difference between the transit times is proportional to the flow velocity and the volumetric flow rate. Accordingly, the direction and magnitude of flow are determined by use of digital signal-processing techniques and software that utilizes the known proportionality between transit times and flow velocity for the given fluid, physical conditions, and pipe size.

Unlike turbine flowmeters, the ultrasonic transducers can be easily and quickly relocated, and can be used to measure flow rates over a wide range without loss of accuracy at high or low rates. An additional advantage afforded by the ultrasonic system is the ability to detect partial or total loss of fluid from a pipe.

This technique was employed to accurately determine hypergol oxidizer and fuel loading during preflight space-shuttle operations. Benefits of ultrasonics include flexibility, cost-efficiency, reliability, and hazard-free hyperol operation. This technology also proved valuable in the determination of extremely low flow rates through the space-shuttle water-coolant-loop floodlight cold plate used for cooling the crew compartment.

This work was done by Rudy J. Werlink of **Kennedy Space Center** *and Ravi N. Margasahayam formerly of I-NET, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Programs and Commercialization Office, Kennedy Space Center, (407) 867-6373. Refer to KSC-11926.

High-Temperature Pressure Sensors Made From Silicon Carbide

Working temperatures range up to 500 °C.

John H. Glenn Research Center, Cleveland, Ohio

Pressure sensors that contain thin diaphragms made from the 6H polytype of silicon carbide (6H-SiC) have been developed. These are prototypes of pressure sensors for use at high temperatures in engines, power plants, material-processing systems, and numerous other applications.

The wide band gap (3.0 V), high breakdown electric field (2.5 MV/cm), and high electron saturation speed (2×10^7 cm/s) of 6H-SiC make it a superior candidate material for high-temperature electronic devices. In addition, SiC exhibits excellent thermal and mechanical

properties at high temperatures and large coefficients of piezoresistance — a combination of properties that makes this material suitable for high-temperature electromechanical sensors.

The prototype SiC pressure sensors were batch-fabricated by micromachining and demonstrated to work at temperatures from room temperature up to 500 °C. The 6H-SiC starting material (i.e., wafers) have micropipes in them. The processing conditions applied in this work plugged the micropipes, thereby making the 6H-SiC material useable.

The SiC pressure sensors offer the following five major advantages in addition to those mentioned above:

1. Junction leakage, which renders silicon semiconductor devices inoperative at high temperatures, is insignificant because of the wide band gap of 6H-SiC.
2. The low hole mobility [50 $cm^2/(V{\cdot}s)$] of a lightly-p-doped diaphragm makes the diaphragm highly resistive to planar electric current.
3. Because the results of bulk micromachining are reproducible, batch production offers advantages of low cost, short processing time, and high yield.
4. Because of the homogeneity of bulk micromachined 6H-SiC, these pressure sensors are not subject to the adverse effects of thermal-expansion mismatches, which can be problematic in devices made from heterogeneous materials.
5. Plastic deformation of SiC is not known to occur at the upper end of the temperature range of interest. Consequently, the diaphragms in these sensors remain effective force collectors, even at this high temperature.

This work was done by Anthony A. Ned, Anthony D. Kurtz, and Robert S. Okojie of Kulite Semiconductor Products, Inc., for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16772.

Piezoelectric Igniter/Pressure-Sensor Devices

These devices would supplant conventional spark plugs in internal-combustion engines.

John H. Glenn Research Center, Cleveland, Ohio

Piezoelectric devices that would serve as spark plugs, power generators for spark plugs, and/or pressure sensors have been proposed for use in internal-combustion engines. Unlike conventional spark plugs, these devices would function without need for wire connections to external high-voltage sources. Also, unlike conventional spark plugs, these devices could function without need for external timing circuitry, and/or could function as parts of timing circuitry.

The most basic device of this type would be a self-timing, self-power-generating spark plug. The device would be mounted in a cylinder in an internal-combustion engine, in the manner of a conventional spark plug. The device would include a piezoelectric component with spark electrodes connected to its poles. The increase in pressure during the compression phase of the engine operating cycle would impose a strain on the piezoelectric component of the device and thereby give rise to a voltage between the electrodes. The voltage would increase with pressure until it was sufficient to cause a spark that would ignite the compressed fuel/air mixture in the cylinder. To increase the available voltage, the device could include a striker that would be driven by the increase in pressure to impinge on the piezoelectric component.

Immediately after ignition, the piezoelectric component would generate a voltage in response to the rapid increase in pressure associated with the combustion process. This voltage could be monitored to determine whether the engine is operating properly. The piezoelectrically generated voltage could also be monitored before as well as after sparking for more comprehensive monitoring of engine operation and, in particular, to detect such anomalies as pre-ignition, misfire, and knock.

The pressure-indicating piezovoltage could also be used, in conjunction with other indications of engine performance, to modify the spark timing. In a

variation of the basic concept, the piezovoltage generated during the compression phase would initially be used to charge a capacitor; subsequently, under control by a timing circuit, the capacitor would be discharged through the spark electrodes. The spark timing could be in response to any combination of (1) the engine crank angle, (2) the pressure (as indicated by the piezovoltage), and (3) the rate of change of pressure.

This work was done by Jacob van Reenen Pretorius and Marthinus Cornelius van Schoor of Midé Technology Corp. for **Glenn Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16760.

Lightweight, Low-Power, Inexpensive Ozone Dosimeters

Ozonolysis of organic dyes would cause color changes, which would be measured.

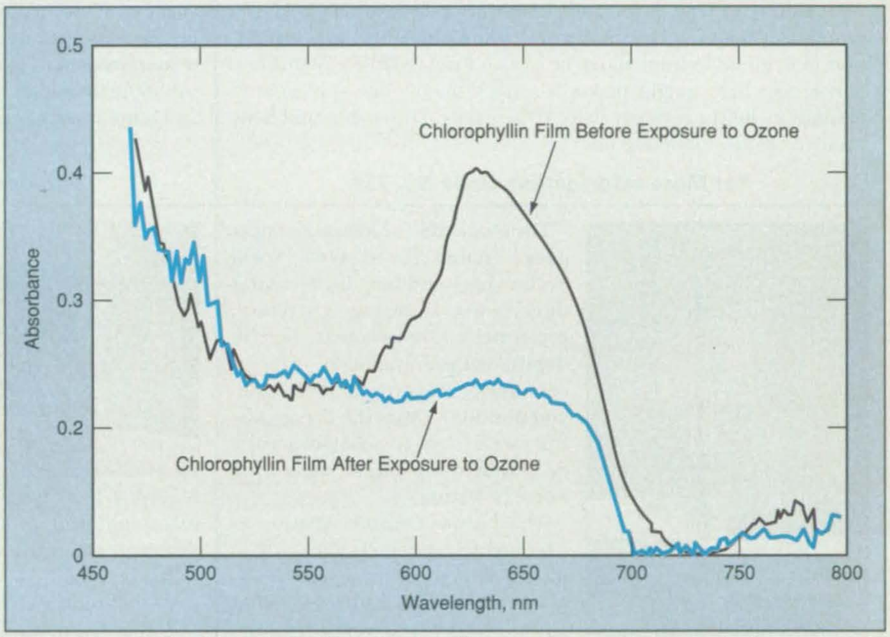
NASA's Jet Propulsion Laboratory, Pasadena, California

Lightweight, low-power-consumption, inexpensive ozone sensors based on colorimetric chemical sensing would be developed, according to a proposal. Colorimetric chemical sensing is an established technique, but it has not been applied previously to sensing of ozone. The proposed ozone sensors could be incorporated into radiosondes for measuring tropospheric and stratospheric ozone concentrations; they could also be used to monitor ozone in a variety of indoor and outdoor environments near such ozone sources as electric-arc welding equipment, high-voltage laboratory instruments, photocopiers, laser printers, and electrostatic air cleaners.

An ozone sensor as proposed would include a transparent substrate (e.g., a glass or plastic slide) coated with an organic dye that changes color when it reacts chemically with ozone. The coated substrate would be illuminated by one or more light-emitting diode(s) or diode laser(s) of the appropriate wavelength(s), and the portion of incident light transmitted through the coated substrate at each wavelength of interest would be measured by a photodiode. The color change would manifest itself as a change in absorbance, and thus a change in the amount of transmitted light at each wavelength of interest. A change in absorbance at each wavelength of interest would be related to the degree of reaction and thus to the ozone dosage via the Beer-Lambert law:

$$A = \alpha lc = \ln(I/I_0),$$

where A is the change in absorbance, α is the dosage-dependent change in the absorption coefficient of the dye, l is the thickness of the layer that contains the dye, c is the concentration of the dye in the layer, I_0 is the intensity of transmitted light before exposure to ozone, and I is the intensity of transmitted light after exposure to ozone.



The **Absorbance of a Chlorophyllin Film** on a glass slide was measured before and after exposure to ozone. The fall of the 630-nm peak and the rise of the 500-nm peak can be interpreted in terms of ozone dosage.

An ozone sensor should operate without interference by oxidizing substances other than ozone (e.g., halogens, SO_2, and NO_2). Therefore, the dye should be either one that does not exhibit color changes in the presence of the other substances, or else one for which the color change induced by ozone differs measurably from the color change(s) induced by the other substances. A promising dye of the latter type is chlorophyllin — a copper-containing, water-soluble derivative of chlorophyll.

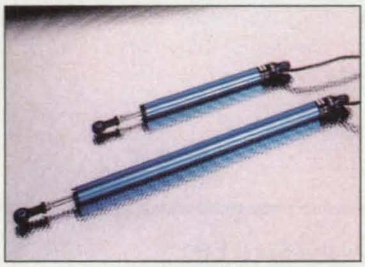
Chlorophyllin exhibits an absorption peak at a wavelength of 630 nm. This peak diminishes in proportion to the degree of reaction (see figure), making it possible to quantify the ozone dosage via the Beer-Lambert law. In addition, the product of ozonolysis of an ethylene group on the chlorophyllin molecule gives rise to a smaller absorption peak at 500 nm; the corresponding absorption peaks induced by other oxidizing species occur at different wavelengths. Thus, one could use the 500-nm peak to verify that the observed color change was caused by ozone or, alternatively, one could identify the oxidizing species by measuring the different wavelength of this peak.

Because the color change would be irreversible and proportional to the cumulative exposure to ozone, a sensor of this type would be a dosimeter (as distinguished from a concentration meter). However, it may be possible to determine the instantaneous concentration of ozone from the rate of change of the absorbance.

This work was done by Margie Homer, Margaret A. Ryan, and Roger Williams of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

NPO-20469

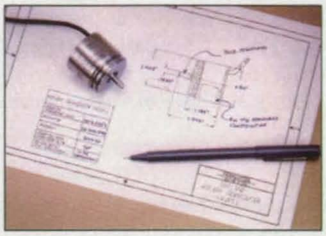
Special Coverage: Sensors



Penny + Giles Controls, Schaumburg, IL, has introduced the SLS190 **sealable linear sensor** that uses hybrid track technology, and features stroke lengths from 25 to 350 mm in increments of 25 mm. The sensor is designed for system designers requiring analog position feedback. It can be specified with a compact shaft option, which offers a reduced mounting dimension.

The sensor features a molded, one-piece rear bearing assembly with integral cable exit which, when used with the shaft seal option, provides sealing to IP66. A rotatable shaft with a mechanical stroke is 4 mm longer than the electrical stroke to simplify set-up and installation. A removable front slider bearing housing allows easy maintenance, and light weight makes it suitable for mobile applications. Options include a compact shaft, IP66 sealing, 10-m cable, and body clamp or flange mounting kits.

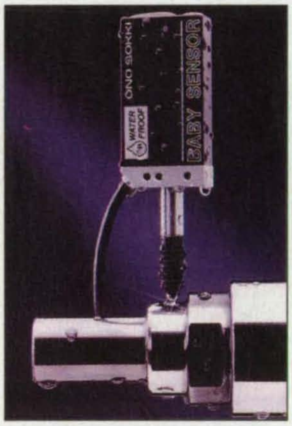
For More Information Circle No. 738



The Series U-222xxx **rotary position sensors** from Transicoil, a division of Horizon Aerospace, Norristown, PA, are available in sizes from 0.8" (Size 8) to 1.5" (Size 15) in diameter. The Size 15 has a temperature range from -50 to +275°F, excitation of 20V RMS, and frequency of 3000 Hz. Its operating range is from 0 to 90° of rotation. At 0° displacement, its output voltage is 8.2 VRMS, and at 90°, it is 11.8 VRMS.

Constructed of 416 stainless steel with a 303 stainless steel shaft, the sensors operate with an ac voltage energizing a two-part winding surrounding a specially shaped rotor. As the position of the rotor changes, it changes the magnetic resistance of the winding. An output signal is measured across a portion of the winding, and its voltage is proportional to the position of the rotor and the shaft. Users can specify temperature and pressure ranges, shielding, and excitation and output parameters.

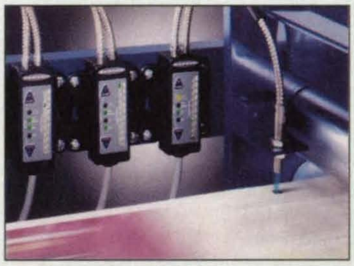
For More Information Circle No. 740



The Model BS-112 **miniature linear gauge sensor** from Ono Sokki Technology, Addison, IL, measures dimensions, thickness, curvature, eccentricity, displacement, height, depth, flatness, variation, runout, roundness, distortion, deflection, and position. It uses the linear glass scale technology to maintain accuracy through the entire measuring range of 10 mm.

The ultra-compact sensor is designed for extremely tight spaces, such as mounting inside machinery. A waterproof seal and dust bellow are provided for accurate measurement in harsh environments. An air or mechanical release cable may be used to raise and lower the measuring probe. The sensor comes with a 6-foot signal cable that can be connected to remote displays with various outputs.

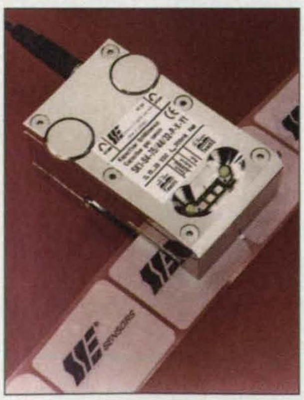
For More Information Circle No. 737



Banner Engineering Corp., Minneapolis, MN, offers the R55F Series **fiber-optic color mark sensors** that can detect 16 levels of gray scale at up to 10,000 actuations per second. Models with glass fibers can be used in harsh environments; plastic fiber models are used in applications requiring fiber flexing capabilities, such as in robotics. All adjustments are made to the sensor on the front panel. The sensors can detect all colors using a choice of red, green, white, or blue visible sensing beams.

A teach function provides two operator options: Static Teach and Dynamic Teach. Static Teach is used to set sensing conditions manually, and Dynamic Teach enables users to "teach" the sensor a series of conditions, average the sensing events, and set and periodically update the threshold between light and dark conditions. The sensors operate in temperatures from -10° to +55°C.

For More Information Circle No. 736



A self-teach **capacitive label sensor** from SIE Sensors, Toledo, OH, is a non-contact, non-infrared sensor with a tape speed averaging up to 500 meters per minute. A three-LED display allows for easy set-up. The sensor operates at 10-30 VDC and is available in PNP or NPN outputs, which are switchable from normally open to normally closed. The sensor detects transparent or color labels, and tears or splices.

The unit features temperature and humidity compensation, short circuit protection, and a static switching output. The sensor is offered in two versions with optional slot widths of 0.4 mm and 0.6 mm. The unit housing is made of nickel-plated aluminum, which separates for compact installation. For optional wiring purposes, an M8 quick-disconnect with an additional LED indicator is a standard feature.

For More Information Circle No. 739

Hyde Park Electronics, Dayton, OH, has introduced the Model CT-1000 Series of **ultrasonic counting sensors**, which feature a dual-transducer design. The sensor counts both separated and back-to-back containers at line speeds up to 2000 per minute. The sensor output can be used with most counters or totalizers. Containers may be of any shape, material, color, or style, and sized from 1" to 12" in diameter.

The sensing range, to the inside of the pass-line rail, is 2" to 2.75". Made of ULTEM® plastic, the sensor housing measures 4.45 x 2.54 x 3.10". During operation, a two-digit numeric display shows either counting activity or errors. The sensor provides both a sinking (NPN) and a sourcing (PNP) output. Available in either cable or connector style, the sensor is sealed to withstand dust, humidity, and high pressure.

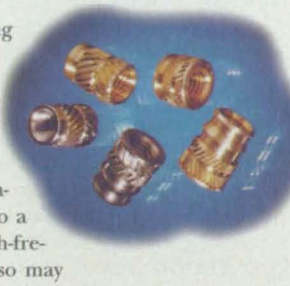
For More Information Circle No. 735

New on the MARKET

Ultrasonic Flowmeter

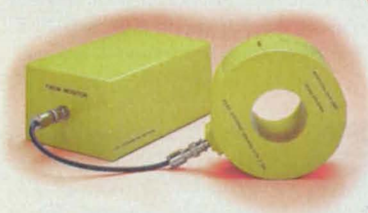
The FD610 Series flowmeter from OMEGA Engineering, Stamford, CT, features trans-phase measuring technology designed for accurate flow-velocity assessments in closed piping systems. Its non-invasive, clamp-on transducer is placed on the outside of the pipe. Within seconds, the 18mm LCD provides readings in either feet or meters per second. The meter works with either metal or plastic pipes containing liquids with more than 25 ppm of 30-micron (or larger) suspended solids or entrained gases. **Circle No. 701**

Threaded Inserts



Penn Engineering & Manufacturing Corp., Danboro, PA, offers SI ultrasonic threaded inserts for assembly and disassembly of electronics, automotive, aerospace, and communications equipment. The brass or stainless-steel inserts can be installed ultrasonically by pressing the fastener into a mounting hole while applying high-frequency vibration. A thermal press also may be used to create the heat necessary for installation. The inserts are available in a range of thread sizes and can be used in tapered and straight holes. **Circle No. 702**

Current Monitor



Ion Physics Corp., Atkinson, NH, has introduced the CM-001-ES current monitor, which measures peak currents at line frequencies up to 150 kilo-amps, and RMS currents at 60 Hz up to 20 kilo-amps. The monitor uses an air-core design with an inner diameter of 2" and an outer diameter of 5". When placed around the current-carrying conductor, the monitor senses the magnetic field associated with the current, measuring the current without a direct connection. The CM-001-ES can be used wherever very high currents must be measured between 5 Hz and 1,000 Hz. **Circle No. 706**

Color Industrial Camera

Vision Components, Cambridge, MA, has introduced the VC65/C color industrial smart camera. The machine vision system features 24-bit RGB color capabilities and a progressive scan sensor. The camera, which measures 117 x 50 x 36 mm, includes up to 8 MB of RAM and 2 MB of Flash EPROM. Its CCD sensor provides 782 x 582 RGB pixels, shutter speeds from 1/100,000 to 20 seconds, and a DSP. Other features include optically isolated industrial I/O, an RS-232 serial interface, CCIR video output, and pixel-identical sensor read-out. **Circle No. 708**

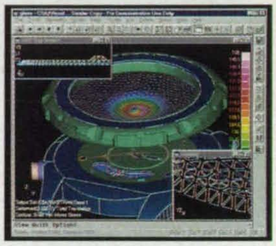
For More Information Circle No. 438

New on DISK

Presentation Software

Canvas 7 from Deneba Software, Miami, FL, is an integrated vector illustration, image editing, Web design, page layout, and presentation application. The release introduces next-generation Sprite technology, called SpriteEffects™, and includes more than 150 new features, tools, and performance enhancements. SpriteEffects allows users to apply unlimited numbers of imaging filters to any object. Other features include new GIG and JPEG export capabilities, HTML support, new drawing tools, and multiple options for importing Photoshop files. **Circle No. 712**

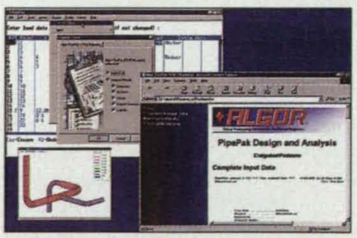
FEA Integration for AutoCAD



CSA/Visual for AutoCAD from CSAR, Agoura, CA, is a FEA implementation for seamless 2D and 3D AutoCAD, AutoCAD LT, and Mechanical Desktop models. It is designed to integrate core FEA features such as beams and rigid elements with the AutoCAD interface. With seamless integration of CSA/NASTRAN and AutoCAD, complex assemblies and multiple materials can be analyzed within a common interface. Manual translation is eliminated by utilizing native geometry, which reduces training and analysis time. **Circle No. 713**

Application Development

BrainTech, North Vancouver, BC, Canada, has released version 3.0 of the ODYSEE Development Studio, a drag-and-drop environment for application development. Features include an integrated environment with GUI builder; online debugging and optimization; ODYSEE-wrap, a tool for integrating C/C++ functions; and a component-based architecture. Third-party libraries can be purchased with ODYSEE, which enables users to leverage expertise from more than 3,000 functions. **Circle No. 714**

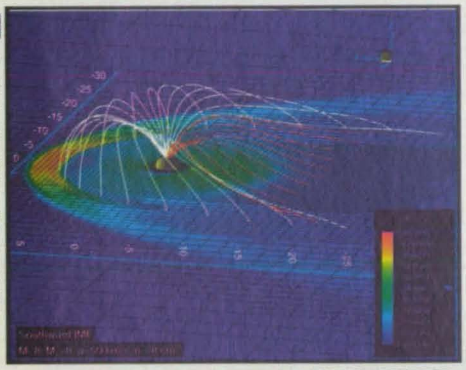


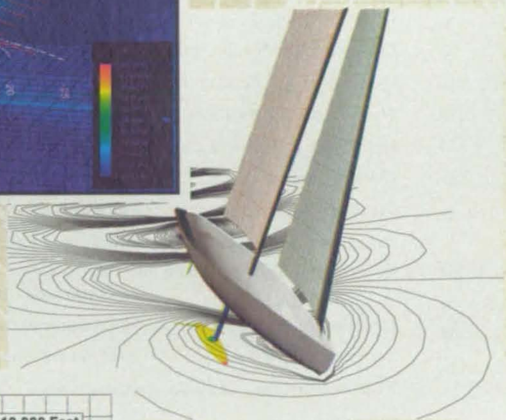
Piping Design and Analysis

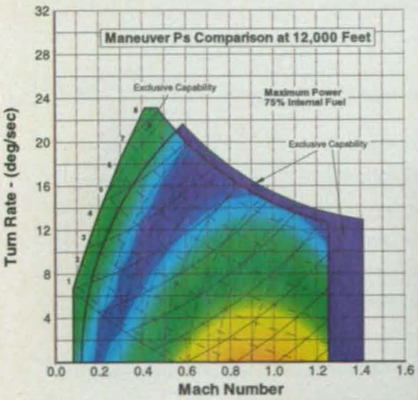
Algor, Inc., Pittsburgh, PA, has released PipePak 7.0, a piping design and analysis software package featuring a new HTML Report Wizard, which creates formatted, customizable reports that can be displayed using any Web browser. PipePak 7.0 saves model images in formats such as JPEG, TIF, PCX, PNG, TGA, and BMP. Improved arc functionality allows users working in Superdraw III — Algor's single user interface and piping design tool — to export models to PipePlus, PipePak's ASME piping-analysis processor. An improved user interface ties all PipePak 7.0 elements into one menu accessible from within Superdraw III. **Circle No. 716**

Business Visualization

OpenViz™ from Advanced Visual Systems, Waltham, MA, provides dynamic, interactive, and scalable 2D and 3D representations of multiple data and chart types. This suite of components allows IT organizations and developers to Web-enable applications by creating lightweight applets and ActiveX controls. OpenViz supports both JavaBeans and COM/ActiveX with a single, common user interface. Interactive charting and graphing capabilities allow end users of OpenViz-developed applications to interact with data, rather than viewing it passively. Users can create "what-if" scenarios or manipulate axes and scales to create multiple displays for any data set. **Circle No. 717**



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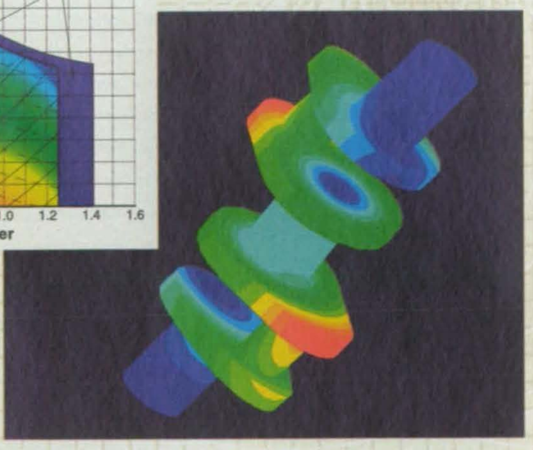

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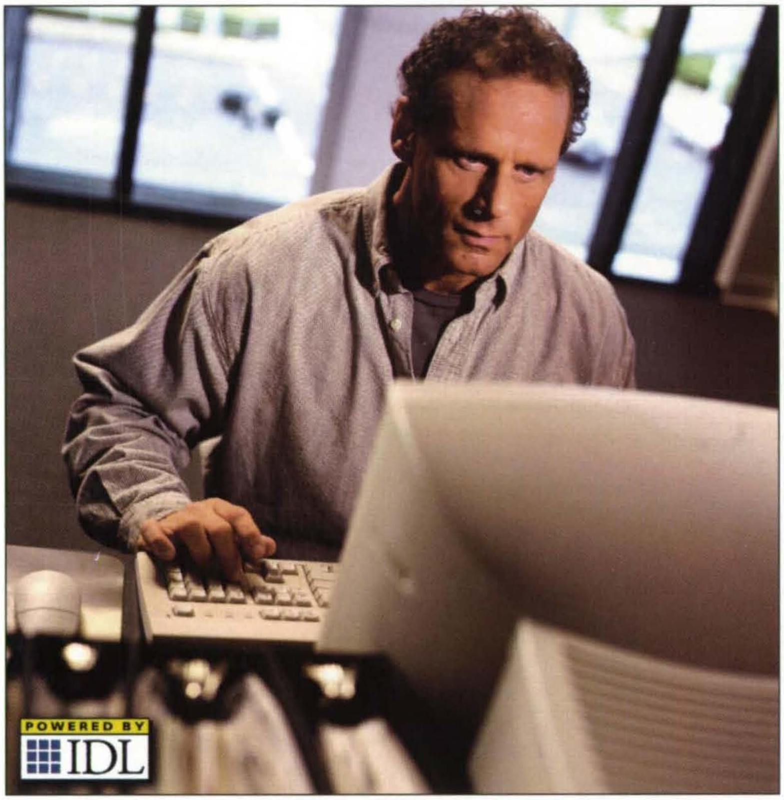

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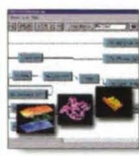

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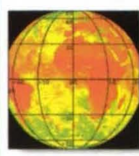

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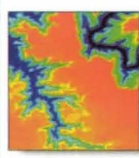

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